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ENVIRONMENTAL MONITORING STUDIES OF SELECTED PESTICIDE SPRAY OPERATIONS IN BRITISH COLUMBIA

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By

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ABSTRACT

This report summarizes the results of chemical residue and biological measurements in a selected number of operational and experimental pesticide spray applications in British Columbia. The chemical measurement data obtained during herbicide applications were used for the development of buffer zone guidelines to protect salmon and trout fishery habitat areas. Spray drift patterns, air, sediment and water contamination, and persistence of herbicides in the aquatic and terrestrial environments were studied. The impact of certain insecticides on aquatic and terrestrial invertebrates was investigated to evaluate the effects of spray operations on these organisms.

Twenty-eight different studies are summarized in seven appendices covering the following pesticide programs: forestry conifer release, rights-of-way vegetation control, forestry insect pest control, mosquito control, agricultural-urban pest control, aquatic pest control and industrial/commercial vegetation and pest control. The body of the report summarizes the results of these investigations, and provides a general assessment of the findings of the monitoring studies.

RÉSUMÉ

Le présent rapport contient le résultat des études visant à mesurer les résidus chimiques et les effets biologiques produits par une sélection de pulvérisations opérationnelles et de pesticides expérimentales, faites en Colombie-Britannique. On s'est servi des résultats recueillis sur les résidus chimiques laissés par les applications d'herbicides pour élaborer un ensemble de directives visant à l'établissement d'une zone tampon destinée à protéger les secteurs d'habitat du saumon et de la truite. On a procédé à une étude du mode de dissémination des herbicides, de la contamination de l'air, des sédiments et de l'eau, ainsi que de la persistance des herbicides dans les milieux aquatique et terrestre. On a également étudié l'effet de certains insecticides sur les invertébrés vivant en milieux aquatique et terrestre, afin de déterminer le résultat des pulvérisations sur ces organismes.

Vingt-huit études différentes ont été condensées sous la forme de sept appendices couvrant les applications suivantes de pesticide: dégagement des conifères, élimination de la végétation le long de certaines voies de passage, répression des insectes forestiers nuisibles, destruction des moustiques, lutte contre les insectes nuisibles en zones agricoles, urbaines et aquatiques, élimination de la végétation et des insectes nuisibles dans les quartiers industriels/commerciaux. Le compte rendu des résultats de ces différentes études forme l'essentiel du rapport qui fournit une évaluation d'ensemble des données recueillies.

TABLE OF CONTENTS

		Page
ABSTRACT		i
RÉSUMÉ		ii
TABLE OF CONTENTS		iii
	List of Tables	vi
	List of Figures	vii
CONCLUSIONS		viii
1	INTRODUCTION	1
2	DISCUSSION	3
2.1	Herbicide Application Techniques and Buffer Zone Requirements to Protect Fishery Sensitive Habitat	3
2.2	Pesticide Persistence and Environmental Contamination	12
2.3	Impact of Operational and Experimental Use of Some Pesticides on Selected Non-target Organisms in B.C.	18
ACKNOWLEDGEMENTS		23
APPENDICES		24
APPENDIX I	FORESTRY CONIFER RELEASE PROGRAMMES	24
	Study No.1 - Helicopter application, 2,4-D/2,4,5-T, Squamish	25
	Study No.2 - Helicopter application, 2,4-D/2,4,5-T, Toba Inlet	29
	Study No.3 - Helicopter application, 2,4-D/2,4,5-T, Holberg	32
	Study No.4 - Helicopter application, 2,4-D, Toba Inlet	36

Page

Study No. 5 - Helicopter application, Glyphosate, Lower Fraser Valley 42

APPENDIX II RIGHTS-OF-WAY VEGETATION CONTROL PROGRAMMES 48
  Study No.6 - Mistblower application, 2,4-D/2,4,5-T, Nitinat 49
  Study No.7 - Powerhose application, Picloram Triazines, Hwy. No. 1, 3, 5 56
  Study No.8 - Boom application, Atrazine, CNR 57
  Study No.9 - Boom application, Tebuthiuron, BNR 58
  Study No.10 - Fixed Wing application, 2,4-D/2,4,5-T, Sechelt 61
  Study No.11 - Fixed Wing application, 2,4-D/Picloram, McLeese Lake 65
  Study No.12 - Helicopter application, 2,4-D/2,4,5-T, Pemberton 69
  Study No.13 - Boom application, Dicamba, Boundary Bay Airport 74

APPENDIX III FORESTRY INSECT PEST CONTROL PROGRAMMES 76
  Study No.14 - Fixed Wing application, Fenitrothion, Quatsino Sound 77
  Study No.15 - Fixed Wing application, Altosid, Revelstoke 80
  Study No.16 - Fixed Wing application, Orthene/Dimilin, Kamloops 84

APPENDIX IV MOSQUITO CONTROL PROGRAMMES 87
  Study No.17 - Fixed Wing & Ground application, Abate/Malathion, Delta, Kamloops, Tsawwassen, Matsqui, Port Coquitlam 88

Page

Study No.18 - Fixed Wing & Ground application, Dimilin, Port Coquitlam 92

APPENDIX V AGRICULTURAL-URBAN PEST CONTROL PROGRAMMES 98
Study No.19 - Boom application, Selected Pesticides, Sumas Prairie 99
Study No.20 - Boom/Powerhose application, Selected Pesticides, Richmond 103
Study No.21 - Combine Seed Spreader, Hexachlorobenzene, Peace River region 106

APPENDIX VI AQUATIC PEST CONTROL PROGRAMMES 108
Study No.22 - Backpack application, Selected Pesticides, Okanagan Lake 109
Study No.23 - Hand application, $CuSO_4$, Cultus Lake 113
Study No.24 - Spin spreader, 2,4-D, Wood Lake and Kalamalka Lake 119
Study No.25 - Spin spreader, 2,4-D, Wood Lake and Kalamalka Lake 129
Study No.26 - Spin spreader, 2,4-D, Okanagan Lake 135

APPENDIX VII INDUSTRIAL/COMMERCIAL VEGETATION AND PEST CONTROL PROGRAMMES 141
Study No.27 - Powerhose, Boom Spray application, Tebuthiuron, Ingledow Hydro Substation, Surrey 142
Study No.28 - Boom application, Dursban, Vancouver International Airport 144

APPENDIX VIII BIBLIOGRAPHY 148

LIST OF TABLES

Table		Page
1	HERBICIDE DRIFT FROM PLOT BOUNDARIES USING DIFFERENT SPRAY EQUIPMENT AND SUGGESTED BUFFER ZONES REQUIRED TO PROTECT FISHERY SENSITIVE AREAS	6
2	PERSISTENCE OF FIELD APPLICATION(S) OF SELECTED PESTICIDES IN BRITISH COLUMBIA ENVIRONMENTS	15
3	IMPACT OF SELECTED PESTICIDES ON NON-TARGET ORGANISMS IN BRITISH COLUMBIA ENVIRONMENTS	21

LIST OF FIGURES

Figure		Page
1.	THE "WEE DO" LANCE INJECTOR AND APPLICATION TECHNIQUE	8
2.	"WEE DO" LANCE OPERATION	9
3.	CARTRIDGE ATTACHED TO TREE STEM	9
4.	EFFECTS OF HERBICIDE ON INJECTED TREE	10

CONCLUSIONS

The following conclusions were drawn from the review of the herbicide monitoring studies and form the basis of a buffer zone guideline for the protection of the fishery resource, and the aquatic environment in British Columbia from controlled pesticide use.

1. Herbicide spray drift varies according to the type of operational equipment and nozzle design used. Apart from the prevailing environmental conditions, chemical formulations of herbicides also play an important role in determining the drift pattern. For the protection of fish and fish habitat from pesticide contamination, a minimum 10 meter pesticide free zone is recommended around fishery sensitive wetland areas. In order to achieve this pesticide free zone, the following minimum buffer zones are suggested for the different spray equipment and chemical formulations, (also see Table 1):

SPRAY EQUIPMENT	HERBICIDE FORMULATION	SUGGESTED MINIMUM BUFFER ZONE FROM WETLAND AREAS* (meters)
Boom Sprayer		
Fixed Wing Aircraft	Liquid	200
Fixed Wing Aircraft	Solid	50
Helicopter	Liquid	100
Helicopter	Solid	50
Truck	Liquid	15
Mistblower		
Truck	Liquid	15
Backpack	Liquid	15

Continued...

GUIDELINE (cont.)

SPRAY EQUIPMENT	HERBICIDE FORMULATION	SUGGESTED MINIMUM BUFFER ZONE FROM WETLAND AREAS* (meters)
Power Hose		
Truck	Liquid	15
Individual Tree Treatment		
Hack/Squirt, Frilling Notching, Drilling, Injection, etc.	Liquid/Solid	10

*This guideline was developed and utilized by EPS Pacific Region staff and does not represent National EPS, DOE or federal government policy.

2. The extent of pesticide contamination of the environment varies according to the material used, method of treatment, and the prevailing environmental conditions, (see Table 2). The use of some moderately persistent materials (eg., picloram, triazine herbicides) can result in the contamination of the treated area for up to one year after treatment. Pesticides that are less persistent, (eg., malathion, abate, altosid, phenoxy herbicides) generally disappear within the treatment season. Although the organochlorine pesticides were phased out 5-10 years ago, small quantities of their residues are still detected in certain aquatic environments of British Columbia.

3. It is apparent that short term impact of pesticides on non-target invertebrates occurs after each spray operation (see Table 3). The duration of effects depends on the type of pesticide used and the prevailing environmental conditions. Prolonged reduction of

non-target organisms can occur if herbicides are used to change the habitat (e.g., rights-of-way, vegetation control, brown and burn in forest management). In forestry insecticide spray operations, the effect on non-target insects is temporary because re-population via migration and reproduction from neighboring untreated areas, re-establishes the eliminated non-target species in the treated area. Generally, the long-term impact of many pesticides commonly used in British Columbia is not known since few studies have been conducted to investigate this problem.

4. Since almost all monitoring studies have been conducted on public land in British Columbia, the above conclusions essentially apply to pesticide impact on Crown land, but not on private land, or agricultural land where large quantities of pesticides are also used annually.

5. No major fish kills have occurred for ten years and the present B.C. Pesticide Control Committee permit review system appears to be adequate in preventing short term impacts on non-target organisms. Additional monitoring studies are required to better delineate pesticide pathways through British Columbia environments.

1 INTRODUCTION

Since 1973, the Environmental Protection Service (EPS) of Environment Canada, Pacific Region, has monitored a number of pesticide projects on Crown lands in the province of British Columbia. A permit must be obtained from the British Columbia Pesticide Control Branch prior to any use of pesticides on Crown lands. This permit specifies the conditions of pesticide use on these lands.

EPS reviews provincial permit applications with assistance from the Department of Fisheries and Oceans and provides advice on the protection of the anadromous fishery and the general environment to the British Columbia Pesticide Control Branch. After the permits have been issued, pesticide monitoring studies are conducted to ensure that the conditions in the permits are met. The studies described in this report were undertaken to obtain information to assist in the development of viable guidelines to protect the fishery resource from pesticides. Efforts were therefore directed to obtain the following data on pesticide use in British Columbia:

a) spray drift patterns generated by different application techniques under conditions prevailing in British Columbia coastal areas;
b) pesticide contamination of aquatic ecosystems under various application conditions and pesticide formulations, and
c) impact of selected pesticides on non-target organisms, particularly, invertebrates and fish.

This publication was produced to collate brief summaries of all information obtained by EPS between 1973 and 1982 into a single volume for quick information and easy reference. To enhance the information in this report, selected investigations undertaken by the Fish and Wildlife Branch and Aquatic Studies Branch of the British Columbia Ministry of

Environment, and The National Water Research Institute of the Inland Waters Directorate, Environment Canada, are also included. Details specific to each study are presented in a consistent format providing information on project details, pesticide use, monitoring objectives, study design, summary and conclusions, and report references. A general discussion of the findings of these monitoring studies follows.

2 DISCUSSION

The primary purpose of the monitoring studies was to obtain field information to assess the adequacy and compliance with permit requirements, and to assist in the development of a practical buffer zone guideline to protect fishery and wildlife resources and habitats from the adverse impact of herbicides. Despite some limitations, useful data relating to herbicide drift patterns, persistence, and impact on non-target organisms were obtained. Most important of all, these data were generated under physical, and climatic conditions characteristic to British Columbia coastal regions.

2.1 Herbicide Application Techniques and Buffer Zone Requirements to Protect Fishery Sensitive Habitat

Appendices 1 and 2 summarize thirteen herbicide monitoring studies carried out during conifer release and rights-of-way vegetation control programs. The buffer zone requirements outlined below were determined from these studies, and the reader should review each study in order to gain a better perspective on the following discussion.

The release and distribution of a herbicide to the environment depends on a number of factors, notably, the method of application, chemical formulation, climatic conditions, and topography. Although climatic conditions and topography contribute to a varying degree to the dispersal of herbicides, the method of application and the chemical formulation largely determine the extent of drift.

Aerial application is usually required when large scale herbicide treatments are conducted in remote and inaccessible terrains, e.g., forestry conifer release programmes over large mountainous areas, or vegetation management programmes along stretches of power-line transmission right-of-way. When accessible and more localized areas require specific herbicide treatment, ground controlled spray equipment is normally used, (e.g., spot treatment of specific problem areas).

Of these two methods of herbicide treatment, aerial spray applications can not only produce extensive drift, but also have a high potential of contaminating fishery and wildlife sensitive habitat which are features characteristic to the British Columbia coastal areas. Drift is an inherent problem of aerial treatment because of the great height of herbicide release, high speed of the aircraft, and extensive air turbulence generated by the propellors which increase the distance of travel and volatility of the herbicide. This problem is less extensive and more controllable in ground operations, which are often the more desirable method of herbicide application from an environmental perspective.

In British Columbia aerial herbicide operations are carried out either by fixed wing aircraft or by helicopter application. Our monitoring studies have found that helicopter drift patterns are more controllable than patterns generated by fixed wing aircraft. Helicopters travel at a much slower speed (ie., 50+ kmph versus 160+ kmph) than fixed wing aircraft, and do not generate a disrupting propellor wake.

The formulation of the herbicide is another important factor that determines or limits the extent of drift. Herbicides are primarily used in the liquid or solid form. For better coverage, ease of application, and more rapid absorption, a liquid formulation is generally more often used than a solid formulation. Liquid formulations are usually much more volatile than solid formulations, and with the combination of factors such as height of application, speed of the aircraft, and air turbulance, are more conducive to drift.

As shown in Table 1, our studies have shown that drift of aerial fixed wing applications of the liquid formulation of herbicides extends to more than 150+ metres outside the treatment area. For an adequate protection of fishery sensitive habitat or streambank vegetation, a buffer zone of at least 200 metres is required. On the other hand, if the same formulation is applied by helicopter, drift residues are found 75+ metres outside the plot boundary. Drift of liquid formulations from helicopter application is only about half as extensive as that from fixed wing aircraft and therefore only requires a minimum buffer zone of 100 metres for the protection of fishery sensitive areas.

It is virtually impossible to eliminate drift in aerial spraying of liquid herbicides. However, other studies have shown that this problem can be minimized considerably if the following precautionary measures are undertaken:

1. Proper visual identification of spray plots and designated non-target areas.
2. Aerial survey and ground review of spray plots, spray swathes and patterns.
3. Choice of the appropriate herbicide formulation.
4. Inclusion of a drift control agent where applicable.
5. The use of properly selected, calibrated, and field tested equipment.
6. Continuous monitoring of atmospheric conditions prior to and during the aerial operation.

With the exception of very windy conditions, aerial spray application of the solid formulation of herbicides (eg. pellets) generally results in much less drift than with a liquid formulation. Application of solid formulations therefore require a much smaller buffer zone for the protection of streamside vegetation. As indicated in Table 1, a 50 metre buffer zone is considered adequate for streambank protection.
Ground operations using truck mounted spray booms, mistblowers, backpack sprayers, and power hoses are the most desirable method of liquid herbicide application. As shown in Table 1, drift generated by these methods of application under normal conditions of spray operation is approximately 5+ metres. A buffer zone of only 15 metres is required for the protection of fishery sensitive areas. The height of the spray nozzle or boom above the ground level was found to determine the extent of drift in ground spraying. Nozzles set at 0.15 metres or less produced little or no drift, while those set at 0.45m to 4m generate drift up to 5+ metres away from the point of release.

TABLE 1: HERBICIDE DRIFT FROM PLOT BOUNDARIES OF DIFFERENT SPRAY EQUIPMENT AND SUGGESTED BUFFER ZONES REQUIRED TO PROTECT FISHERY SENSITIVE AREAS

SPRAY EQUIPMENT	HEIGHT OF NOZZLE ABOVE GROUND (metres)	WIND VELOCITY (km.p.h.)	SPEED OF EQUIPMENT OR OPERATOR (km.p.h.)	CHEMICAL FORMULATION	DRIFT FROM PLOT BOUNDARY (metres)	SUGGESTED MINIMUM BUFFER ZONE FROM WET AREA (metres)
Boom Sprayer[1]						
Fixed wing aircraft	20-25	0-5	160+	Liquid	150+	200
Fixed wing aircraft	20-25	0-8	160+	Solid	25+	50
Helicopter	20-25	0-5	50+	Liquid	75+	100
Helicopter	20-25	0-5	50+	Solid	25+	50
Truck	0.45	0-5	10	Liquid	5+	15
Mist Blower[1]						
Truck/backpack	3	0-5	5	Liquid	5+	15
Backpack Sprayer[2]	1-3	0-5	3	Liquid	5+	15
Power Hose[2]	0.45	0-5	3	Liquid	3+	15
	0.15	0-5	3	Liquid	0	10
Hack/Squirt, Frilling, Notching, Drilling, Tree Injection	NA	NA	3	Liquid/solid	0	10 or site specific requirement

[1] Data obtained from chemical measurements in the field.

[2] Data obtained from visual field observations.

From an environmental perspective, the most desirable methods of liquid or solid herbicide application include the hack/squirt, frilling, notching, drilling and tree injection method. While there may be some herbicide release to the environment, there is no spray drift. In the tree injection method both herbicide release to the environment and drift are eliminated. A good example of a tree injection method is the "Wee Doo" lance injector developed by Mr. B. Dillistone of Simon Fraser University (Figure 1). This technique involves the use of a 22 calibre metal casing where a known quantity of pesticide is stored. The casing can be implanted in to a tree trunk by pushing the injector head of the lance against selected areas of the tree trunk (Figures 2-4). The casing is permanently attached to the stem of the tree. Herbicide then enters the plant via sap-osmotic action and is slowly translocated to the other parts of the tree.

Although the use of the tree injection technique may eliminate the problem of drift and chemical release to the environment, it is important that a 10 metre pesticide free zone be observed around fishery sensitive areas, e.g., on both sides of water courses and around lakes. The rationale behind this requirement is to maintain the integrity of streamside vegetation, which is important for the preservation of natural habitat and water quality of fishery sensitive areas. Under special circumstances, however, it may be possible to remove certain problem trees or to kill top growth of specific trees within the 10 metre pesticide free zone. Such a procedure would be subject to the site specific recommendations of representatives of either the Federal Environmental Protection Service, Federal Department of Fisheries and Oceans, or Fish and Wildlife Branch of the British Columbia Ministry of Environment, usually following an on-site inspection.

It should be noted that from the vegetation manager's point of view, it is sometimes impractical to use ground equipment for herbicide application, particularly when large scale chemical treatments are required over large inaccessible areas. Under such circumstances aerial

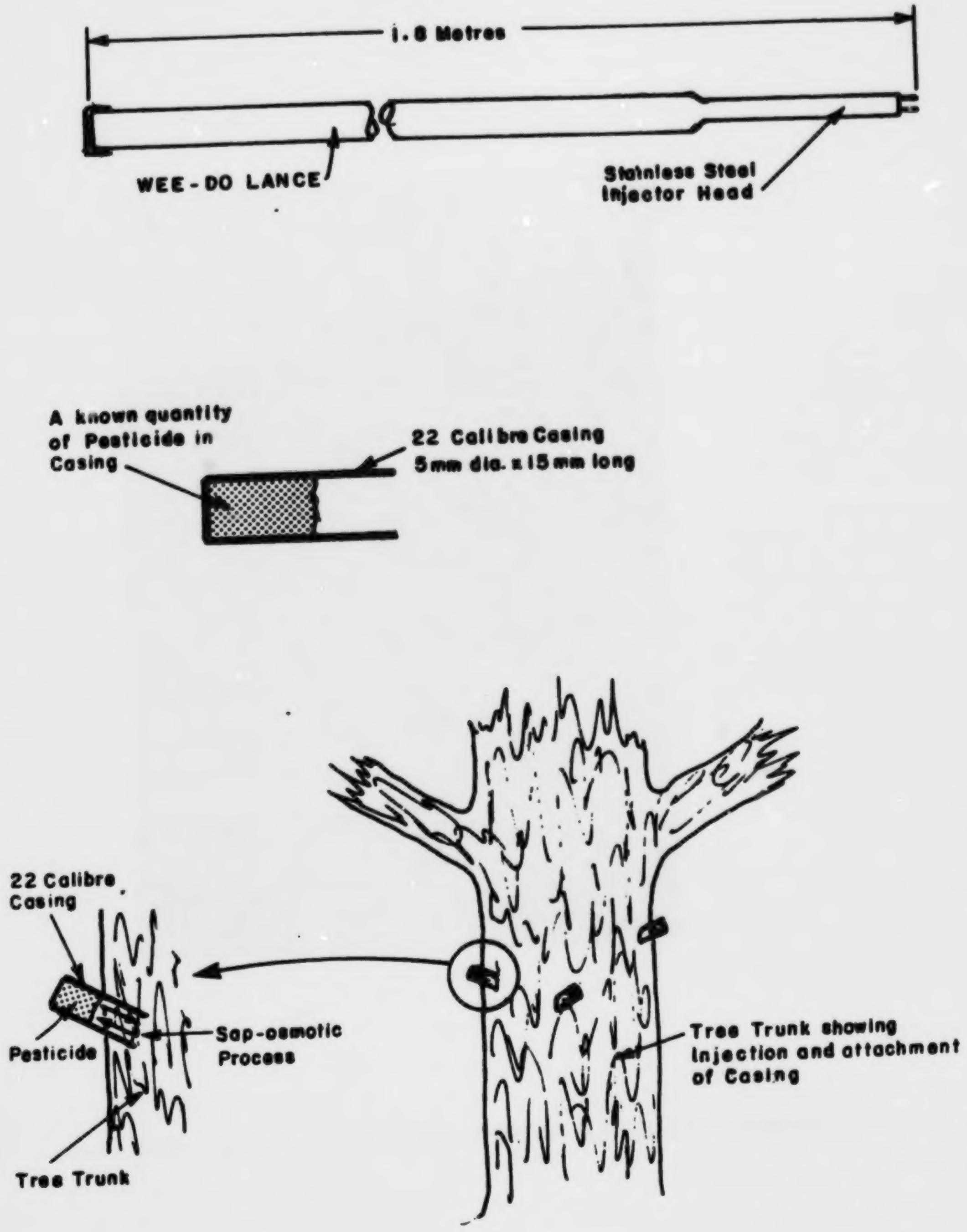
1.8 Metres
WEE-DO LANCE
Stainless Steel
Injector Head
A known quantity
of Pesticide in
Casing
22 Calibre Casing
5mm dia. x 15mm long
22 Calibre
Casing
Pesticide
Sap-osmotic
Process
Tree Trunk
Tree Trunk showing
Injection and attachment
of Casing

FIGURE 1 THE "WEE-DO" LANCE INJECTOR AND APPLICATION TECHNIQUE

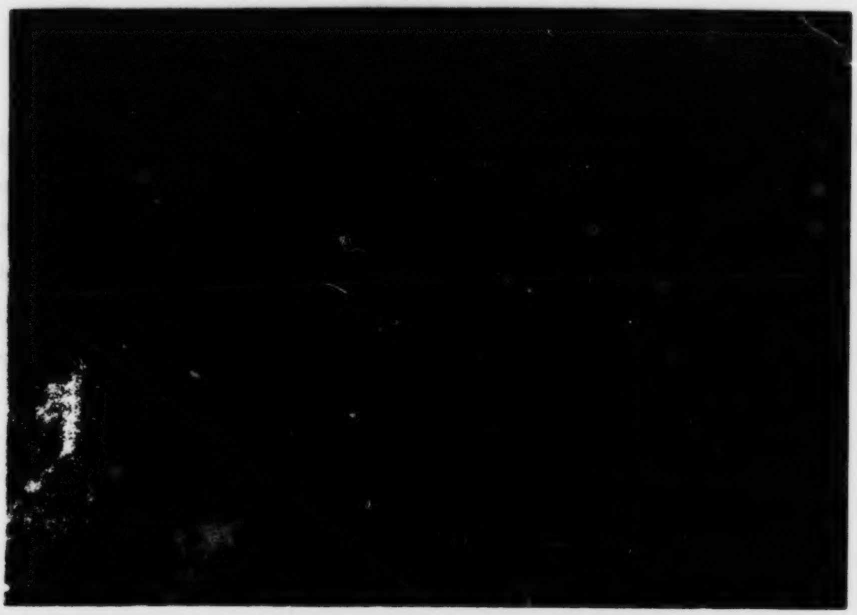

FIGURE 2: LANCE OPERATION - INJECTING 22 CAL. CAPSULE INTO TREE TRUNK

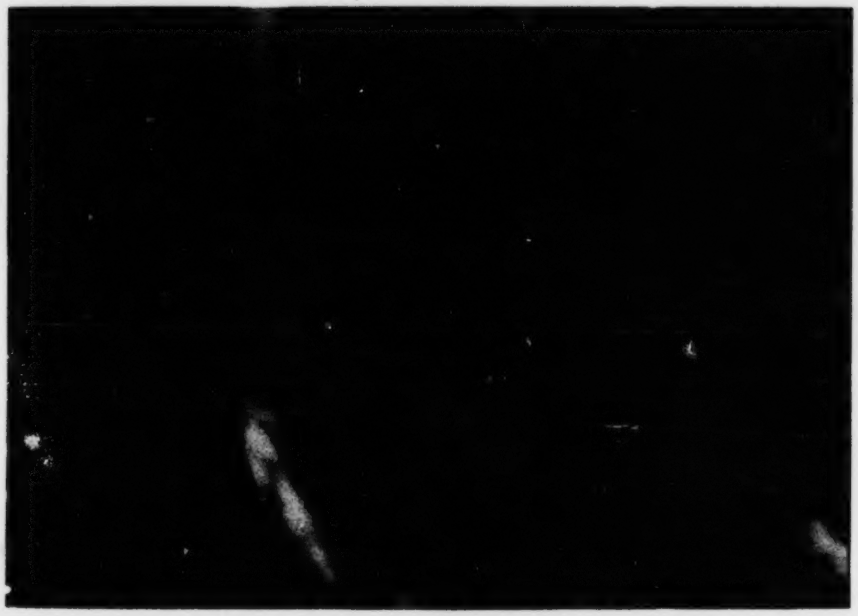

FIGURE 3: CAPSULE REMAINS IN TREE WHILE HERBICIDE IS ABSORBED

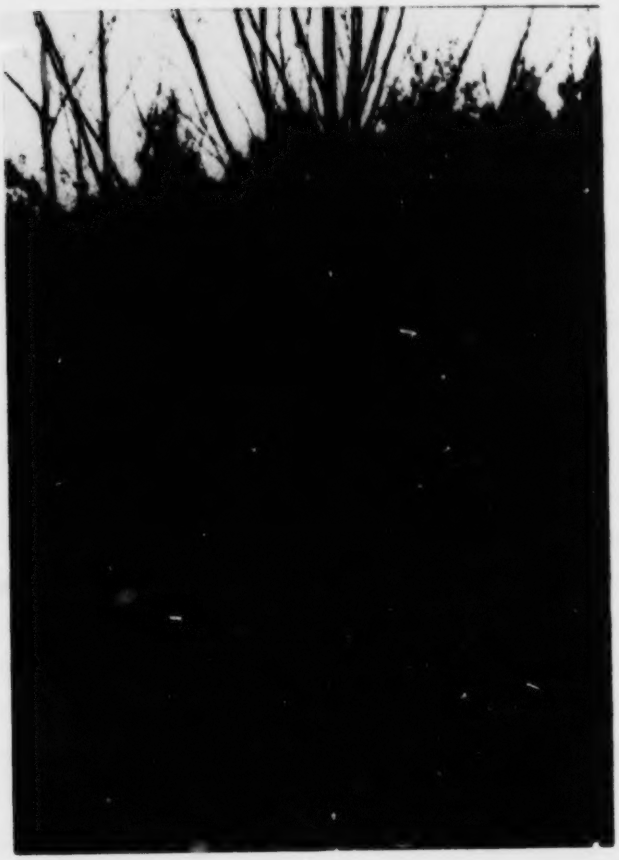

FIGURE 4: KILL FROM "WEE DO" LANCE INJECTION OF GLYPHOSATE (Roundup)

spray application is required. It is our view that helicopter application is the preferred method over fixed wing application for the reasons outlined earlier. For example the much lower contamination of stream buffer zones and creek water observed in Study No. 2 (Toba Inlet) versus Study No. 10 (Sechelt) clearly demonstrates the superiority of the helicopter system versus the fixed wing for aerial application.

2.2 Pesticide Persistence and Environmental Contamination

The studies outlined in Appendices I to VII were conducted to monitor the presence, absence, and residual level of each pesticide at pre-determined periods following treatment. Irrespective of the methods of application, the persistence of pesticides in the environment depends on various factors. The most critical factors are the characteristics of the product (i.e., its chemical structure, bonding, formulations) and the prevailing environmental conditions (i.e., nature of substrate, temperature, pH, biological activity) which influence the pesticide following its release into the environment.

A summary of pesticide persistence in the British Columbia environment is presented in Table 2. Older DDT-type pesticides have very stable chemical bondings which are highly resistant to degradation by physical and biological processes. These compounds were the panacea of pest control in the 1950's and 1960's. As shown in Table 2 under the category of Agricultural-Urban Pest Control Programmes (see also studies 19 and 20, Appendix V), low levels of organochlorine pesticide residues were found in the sediments of Sumas Prairie and Richmond ditches, despite the fact that these materials have not been used for more than ten years. Since the half-life of these products varies considerably (i.e. 3-5 years for chlordane and 10-15 years for dieldrin and DDT), it is expected that small quantities of some of these compounds will remain in the B.C. environment for at least another 10-20 years.

Copper sulphate is another persistent compound that has been used for the control of the hosts of Swimmer's Itch parasite in Cultus Lake for several years (see Study No. 23, Appendix VI). Since elemental copper is indestructible, it is expected that the residues of copper will remain in the sediments of Cultus Lake for an indefinite period of time and will be available for bioaccumulation in certain lake bottom dwelling organisms.

The phenoxy, triazine, and picloram herbicides are the less persistent compounds that are currently used in large quantities over extensive areas for conifer release programmes in forestry and vegetation control, and for soil sterilization projects on rights-of-way in British Columbia. The half-life of these materials as reported in the literature varies from 1-2 months for 2,4-D to 4-5 months for triazine and picloram herbicides. Our rights-of-way monitoring studies found that these materials persisted in the soil of the treated areas for more than one year (Table 2, see also Studies 6, 7, 8, 9, Appendix II).

Various residual levels (e.g., atrazine, 54.8 ppm; 2,4-D/2,4, 5-T, 0.33 ppm; picloram, 0.11 ppm) of some of these materials were detected in certain railway ballast and road shoulders. Some plant species have developed varying degrees of tolerance to these herbicides, and recognizing this problem many users were encouraged to change to newer herbicides, (e.g., Spike (tebuthiuron), glyphosate). Although the triazine herbicides are still effective, they have been used for soil sterilization programmes for about 3 to 5 years, and alternative materials are required in order to reduce the problem of herbicide resistence.

Mosquito control chemicals (abate, altosid, dimilin, malathion) are the least persistent group of pesticides used in British Columbia. Very low concentrations of these chemicals were found in the non-target aquatic environment. Our monitoring studies show that they do not appear to persist beyond 7 days, except for dimilin, which is presently no longer recommended for mosquito control in British Columbia (Table 2, see also Studies 17, 18, Appendix IV).

Our monitoring studies have shown more rapid dissipation of residues in the aquatic than the terrestrial environment where both have been contaminated with a pesticide spray. This difference was particularly evident in running water where pesticides may not be degraded, but diluted below the limit of detection. Even with the use of buffer zones some contamination of the aquatic environment via spray drift can occur. However, residues are usually diluted to concentrations below detection limits within one day.

Pesticide residues transported from treated areas to creeks and streams via runoff also present a potential hazard to fish and aquatic invertebrates. A recent investigation (Study No. 5, Appendix I) indicated that the levels of herbicide residues in creek water and bottom sediment increased substantially following rainfall after the herbicide operation was completed. Mobility of pesticides, however, depends to a great extent on the characteristics of the pesticide (i.e., its chemical bonding property, persistence, solubility in water, and rate of application). This investigation also demonstrated that pesticide transport via runoff could be minimized considerably if the watercourses inside the treatment areas were protected by appropriate buffer zones.

When a pesticide is applied directly to an aquatic environment for a specific purpose, it usually takes a much longer time for the concentrations to fall to levels below the limit of detection. A case in point is the use of 2,4-D butoxyethanol ester (Aqua kleen) for the control of Eurasian Watermilfoil in the Okanagan lakes. Studies have shown that in some areas of Wood and Kalamalka Lakes, it took more than 30-50 days for the herbicide to be diluted to concentrations below the limit of detection in water. There was evidence to suggest that 2,4-D persists in the lake sediments up to 182 days following treatment. This is to be expected since the conditions in the lake bottom are unlikely to be conducive to pesticide degradation, i.e., cold temperatures, light deficiency, and limited biological activity (Table 2, see also Studies 24, 25, 26, Appendix VI).

TABLE 2: PERSISTENCE OF FIELD APPLICATION(S) OF SELECTED PESTICIDES IN BRITISH COLUMBIA ENVIRONMENTS

PESTICIDE	LOCATION	METHOD OF APPLICATION	FORMULATION	SUBSTRATE		RESIDUE LEVEL (PPM) Av. (Range)	PERSISTENCE (Days)
				TARGET AREA	NON-TARGET AREA		
CONIFER RELEASE PROGRAMMES							
2,4-D/2,4,5-T Ester	Squamish	Helicopter	Liquid	-- Soil	Creek Water --	0.001 0.07(0.06-0.08)	0.02 84
2,4-D/2,4,5-T Ester	Holberg	Helicopter	Liquid	--	Creek Water	0.07(0.06-0.08)	0.17
Glyphosate	Maple Ridge	Helicopter	Liquid	--	Creek Water	0.16(0.005-0.023)	1
Glyphosate	Maple Ridge	Helicopter	Liquid	--	Creek Sediment	(0.1-0.4)	90+
RIGHTS-OF-WAY PROGRAMMES							
2,4-D/2,4,5-T Ester Amine	Caycuse	Truck Mounted Mistblower	Liquid	-- Soil	Creek Water --	0.001 0.326(0.04-0.85)	0.08 365+
Picloram	Highway 1, 3, 5	Truck Mounted Boom	Liquid	Soil	--	0.11(0.003-0.54)	365+
Simazine	Highway 1, 3, 5	Truck Mounted Boom	Liquid	Soil	--	0.12(0.04-0.20)	365+
Atrazine	Kamloops	Rail Mounted Boom	Liquid	Soil	--	54.8(0.68-85.5)	365+
Tebuthiuron	Surrey	Rail Mounted Boom	Liquid Emulsion	Soil --	-- Air	4.7 0.06 ug	16+ 0.03
2,4-D/2,4,5-T	Sechelt	Fixed-wing Aircraft	Liquid	--	Creek Water	0.008(0.007-0.009)	0.2
2,4-D	Pemberton	Helicopter	Liquid	--	Creek Water	0.004	L0.001
Dicamba	Boundary Bay	Truck Mounted Boom	Liquid	--	Runoff Water	0.002	3

TABLE 2: PERSISTENCE OF FIELD APPLICATION(S) OF SELECTED PESTICIDES IN BRITISH COLUMBIA ENVIRONMENTS
(Continued)

PESTICIDE	LOCATION	METHOD OF APPLICATION	FORMULATION	SUBSTRATE		RESIDUE LEVEL (PPM) Av. (Range)	PERSISTENCE (Days)
				TARGET AREA	NON-TARGET AREA		
FOREST INSECT CONTROL PROGRAMMES							
Dimilin	Kamloops	Fixed wing Aircraft	Liquid	Soil	--	0.29	8+
MOSQUITO CONTROL PROGRAMMES							
Malathion	Tsawassen	Fixed wing Aircraft	Liquid	--	Pond water	0.001	3
				--	Creek water	0.005	0.02
				Air	--	0.96 ug	0.01
Malathion	Kamloops	Truck mounted Fogger	Liquid	--	Pond water	0.53 ug	0.4
Abate	Tsawassen	Fixed wing Aircraft	Liquid	--	Pond water	L0.001	L1
Altosid	Tsawassen	Backpack	Granular	--	Pond water	0.017	4+
Dimilin	Fort Langley	Fixed wing Aircraft	Granular	--	Pond water	0.0002	71+
				Sediment	--	0.001	71+
Dimilin	Port Coquitlam	Backpack Sprayer	Granular	--	Pond water	0.0001	90
				Sediment	--	0.032	170
AGRICULTURAL AND OTHER PEST CONTROL PROGRAMMES							
DDT	Sumas Prairie	Truck mounted boom	Liquid	--	Sediment	0.007(0.001-0.64)	365+
Endosulfan			Liquid	--	Sediment	0.004(0.001-0.31)	365+
Bromacil			Liquid	--	Sediment	6.8(0.10-94.00)	Seasonal
Tebuthiuron			Liquid	--	Sediment	0.05(0.05-0.99)	Seasonal
Simazine			Liquid	--	Sediment	0.052(0.05-0.090)	365+

TABLE 2: PERSISTENCE OF FIELD APPLICATION(S) OF SELECTED PESTICIDES IN BRITISH COLUMBIA ENVIRONMENTS (Continued)

PESTICIDE	LOCATION	METHOD OF APPLICATION	FORMULATION	SUBSTRATE TARGET AREA	SUBSTRATE NON-TARGET AREA	RESIDUE LEVEL (PPM) Av. (Range)	PERSISTENCE (Days)
AGRICULTURAL AND OTHER PEST CONTROL PROGRAMMES (Continued)							
DDT	Richmond	Truck	Liquid	--	Sediment	5.259(0.015-106.5)	365+
Endosulfan		mounted	Liquid	--	Sediment	0.024(0.020-0.110)	365+
Bromacil		boom	Liquid	Sediment	--	0.25(0.100-49.11)	Seasonal
Tebuthiuron			Liquid	--	Sediment	0.05	Seasonal
Atrazine			Liquid	--	Sediment	0.054(0.050-0.13)	365+
HCB	Peace River Area	Combine seed spreader	Dust	Sediment	--	0.002	365+
AQUATIC PEST CONTROL PROGRAMMES							
Copper	Cultus	Spin	Crystalized	Sediment	--	0.268(0.02-0.516)	365+
	Lake	spreader		Water	--	0.19(0.02-0.30)	0.5
2,4-D	Wood Lake	Spin	Granular	Sediment	--	0.026 - 51	120
		spreader		Water	--	0.051(0.002-0.62)	50
2,4-D	Kalamalka	Spin	Granular	Sediment	--	0.009 - 12	180
	Lake	spreader		Water	--	0.003(0.001-0.009)	31
INDUSTRIAL/COMMERCIAL VEGETATION AND PEST CONTROL PROGRAMMES							
Tebuthiuron	Surrey	Power hose	Liquid	--	Water	L0.01	--
Dursban	Vancouver International Airport	Truck mounted boom	Liquid & Granular	--	Water	L0.001	--

2.3 Impact of Operational and Experimental Use of Some Pesticides on Selected Non-target Organisms in British Columbia Environments

It should be emphasized that this discussion evaluates the short term impact of selected operations and experimental use of some pesticides on non-target organisms such as fish, and aquatic and terrestrial invertebrates inhabiting certain British Columbia environments. No attempt was made to conduct long term impact studies or studies on higher animals.

Like the persistence of pesticides in the environment, the impact of pesticides on non-target organisms also depends on a number of interacting factors, in particular the characteristic of the pesticide, how and where it is applied to the environment, and the type of non-target organisms involved.

The chemical characteristics of a pesticide product, e.g., chemical structure, bonding, and formulation determine the toxicity of a material to an organism. For example, organochlorine, organophosphorus, carbamate type pesticides are designed to be fast acting nerve poisons against insect pests, while other hormonal-type materials act more slowly to disrupt the growth/metabolic processes of developing juvenile insects. Each type of pesticide will therefore have a different impact on non-target organisms.

The method of pesticide release to an environment likewise plays an important function in determining the impact of a pesticide on non-target organisms. Selective treatment such as ground controlled spraying, or spot treatment of problem areas would impact less on non-target organisms than a large scale aerial programme.

As well, the type of non-target organism also has a bearing on the pesticide impact. In general, aquatic and terrestrial invertebrates are much more sensitive to pesticides than larger animals such as mammals. Invertebrates are therefore often used as biological indicators of the environmental quality of a treated area and its vicinity.

A summary of the impact of operational and experimental use of some common pesticides in British Columbia on selected non-target organisms is presented in Table 3. The use of phenoxy herbicides during right-of-way treatment resulted in an initial and partial reduction of the populations of terrestrial invertebrates (see also Study No. 6, Appendix II). As the vegetation succumbs to the effects of the herbicide, a loss of invertebrates occurred as a result of the disintegration of the habitat. Similarly, the use of insecticides, e.g., fenitrothion and orthene in forest pest control, also resulted in a population reduction of non-target insects. In this case however, the effect was only temporary because the spray did not destroy the habitat of these organisms. Regeneration and/or repopulation occurred from migration from neighboring untreated areas (Studies 14, 16, Appendix III). The greatest recorded impact of a pesticide spray on non-target organisms occurred during an aerial mosquito adulticiding operation with malathion. Contamination of the aquatic environment resulted in a fish kill (Study No. 17, Appendix IV).

Although the use of organochlorine pesticides has virtually ceased approximately 12 years ago, minute quantities and residues of these materials are still found in the aquatic environment. The long term effects of low concentrations of these materials on fish and other aquatic organisms in British Columbia is not known. Based on studies conducted elsewhere, these minute residues may be available for long-term bioaccumulation in the aquatic organisms.

The use of chemicals to control aquatic pests is one that has caused some concern. Although the present controlled use of herbicides such as 2,4-D shows no evidence of hazardous effects on fish and wildlife, the potential for permanent impairment of fishery habitat areas is great if the use of large quantities of herbicides occurs on a regular basis.

It should be noted that, except for the fish kill in the adulticiding of mosquitos, there have been no other major pesticide fish kills recorded in British Columbia since 1973. No doubt the current pesticide application review and permit issuing procedures employed in British Columbia are playing an important role in preventing such mishaps. As well, the development and acceptance of appropriate buffer zones assisted greatly in this respect. The data presented in this report also indicate minimal short term effects on non-target organisms, while the long term biological impacts of pesticides are unknown.

TABLE 3: IMPACT OF OPERATIONAL AND EXPERIMENTAL USE OF SELECTED PESTICIDES ON NON-TARGET ORGANISMS IN BRITISH COLUMBIA ENVIRONMENT

PESTICIDE	LOCATION OF OPERATION	METHOD OF APPLICATION	TARGET SPECIES	NON-TARGET SPECIES	ASSESSMENT OF IMPACT ON NON-TARGET ORGANISMS
RIGHTS-OF-WAY PROGRAMME					
2,4-D/2,4,5-T	Caycuse area	Truck mounted mistblower	Roadside Alders	Terrestrial Invertebrates	50 percent reduction of population; long term effects not investigated
FOREST INSECT PESTS CONTROL PROGRAMMES					
Fenitrothion	Neroutsos Inlet area, N. Vancouver	Aerial application	Blackheaded budworm of conifers	Terrestrial Invertebrates	70 percent reduction of population of some groups; long term effects not studied
Altosid	Revelstoke area	Aerial treatment	Western Hemlock Looper	Aquatic Invertebrates	Short term reduced rate of emergence of several groups; long term effects not investigated
Orthene (Acephate)	Kamloops area	Aerial treatment	Douglas Fir Tussock Moth	Arboreal, grass and soil dwelling, and flying insects	Short term total population reduction; long term effects not investigated
Dimilin	Kamloops area	Aerial application	Douglas Fir Tussock Moth	As above	Short term sustained effect on inhibition of emergence of adult insects; long term effects unknown
MOSQUITO CONTROL PROGRAMMES					
Abate	Delta, Matsqui, Port Coquitlam, Kamloops, Tsawwassen	Backpack sprayers, Fogger, Fixed Wing Aircraft	Mosquito Larvae & Adults	Aquatic and Terrestrial Invertebrates	Short term Adverse effect on aquatic Acari, Collembola, Tendipedidae, Diptera, Ephemeroptera, Odonata
Malathion	As above	As above	As above	Fish, Aquatic & Terrestrial Invertebrates	Short term population reduction of terrestrial invertebrates; also caused fish kill

TABLE 3: IMPACT OF OPERATIONAL AND EXPERIMENTAL USE OF SELECTED PESTICIDES ON NON-TARGET ORGANISMS IN BRITISH COLUMBIA ENVIRONMENT (Continued)

PESTICIDE	LOCATION OF OPERATION	METHOD OF APPLICATION	TARGET SPECIES	NON-TARGET SPECIES	ASSESSMENT OF IMPACT ON NON-TARGET ORGANISMS
MOSQUITO CONTROL PROGRAMMES (continued)					
Altosid	Tsawwassen	Backpack sprayer	Mosquito larvae	Aquatic Invertebrates	No apparent short term impact on zooplankton, marsh crabs, fish
Dimilin	Fort Langley	Fixed wing aircraft	Mosquito larvae	Aquatic Invertebrates	Short term suppression of emergence rate of aquatic insects; long term effect not investigated
AGRICULTURAL-URBAN PEST CONTROL PROGRAMMES					
DDT, DDD, DDE, Thiodan	Sumas Prairie	Boom sprayer, etc.	Agricultural pests	Aquatic Organisms	Short term impact not investigated; presence of residues, available for long term bioaccumulation
DDT, DDD, DDE	Richmond	Boom sprayer, etc.	Agricultural-urban pests	Aquatic Organisms	Short term impact not investigated; presence of residues, available for long term bioaccumulation
AQUATIC PEST CONTROL PROGRAMMES					
Paraquat, Dichlobenil Diquat	Vernon Arm of Okanagan Lake	Backpack sprayer	Eurasian water Milfoil	Fish & Aquatic Invertebrates	No evidence of short term adverse effect on fish & aquatic invertebrates; long term effect not studied
Copper Sulphate	Cultus Lake	Spin spreader	Host snails of Swimmer's Itch	Fish & Aquatic Invertebrates	No evidence of fish kill; copper residue available for long term bioaccumulation
2,4-D butoxyethanolester	North Arm of Okanagan Lake	Spin spreader	Eurasian water Milfoil	Fish & Aquatic Invertebrates, Wildlife	No evidence of short term fish or wildlife mortality; long term effect studies in progress

ACKNOWLEDGEMENTS

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APPENDIX I

FORESTRY CONIFER RELEASE PROGRAMMES

Monitoring Study No.	:	1
Monitoring Agency	:	Environmental Protection Service
Proponent of Project	:	Weldwood Canada Limited

PROJECT DETAILS

Location	:	55 km North of Squamish
Purpose	:	Conifer release
Target species	:	Alder, Salmonberry, Coenothus sp., etc.
Treatment area	:	12 ha

PESTICIDE USE INFORMATION

Name of Pesticide	:	2,4-D/2,4,5-T (IOE)
Active Ingredient	:	As above
Rate of Application	:	2.25 kg/ha (ie 2 lbs ai/ac)
Carrier/diluent	:	Water
Drift Control Agent	:	Norbak
Application Method	:	Aerial foliar spray via helicopter
Treatment Date	:	July 5, 1974 (0710 hours)

MONITORING OBJECTIVES

1. To investigate drift of water/drift control herbicide mixture from a helicopter spray in rugged terrain to determine the effectiveness of buffer zones in reducing contamination of water courses.
2. To investigate the persistence of herbicide residues in water and soil.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 1-1 and 1-2.

SUMMARY & CONCLUSIONS

Despite the use of a drift control agent substantial herbicide residues were detected on drift plates at distances greater than 54 meters from the border of the treatment plot. This resulted in the reduction of streambank vegetation and herbicide contamination of a creek. The 30 meter streamside buffer zone specified in the pesticide permit appeared inadequate for the protection of streambank vegetation and aquatic environment. However, in this case, the pilot misdirected some of his spray applications because of poor visibility and placement of buffer zone markers. To maintain streamside vegetation and aquatic integrity, the buffer zone should have been increased to at least 100 meters.

Although residues in stream water disappeared 0.5 hours following herbicide application, those found in the soil persisted for 12 weeks.

Buffer zone markers should be deployed in a manner that is easily recognized by and visible to the pilot.

REFERENCE

Wilson, D.M. & M.T. Wan (1975). Effectiveness of stream buffer zones during aerial applications of chlorophenoxy and picloram herbicides. Environmental Protection Service. E.P.S. 5-PR-75-3.

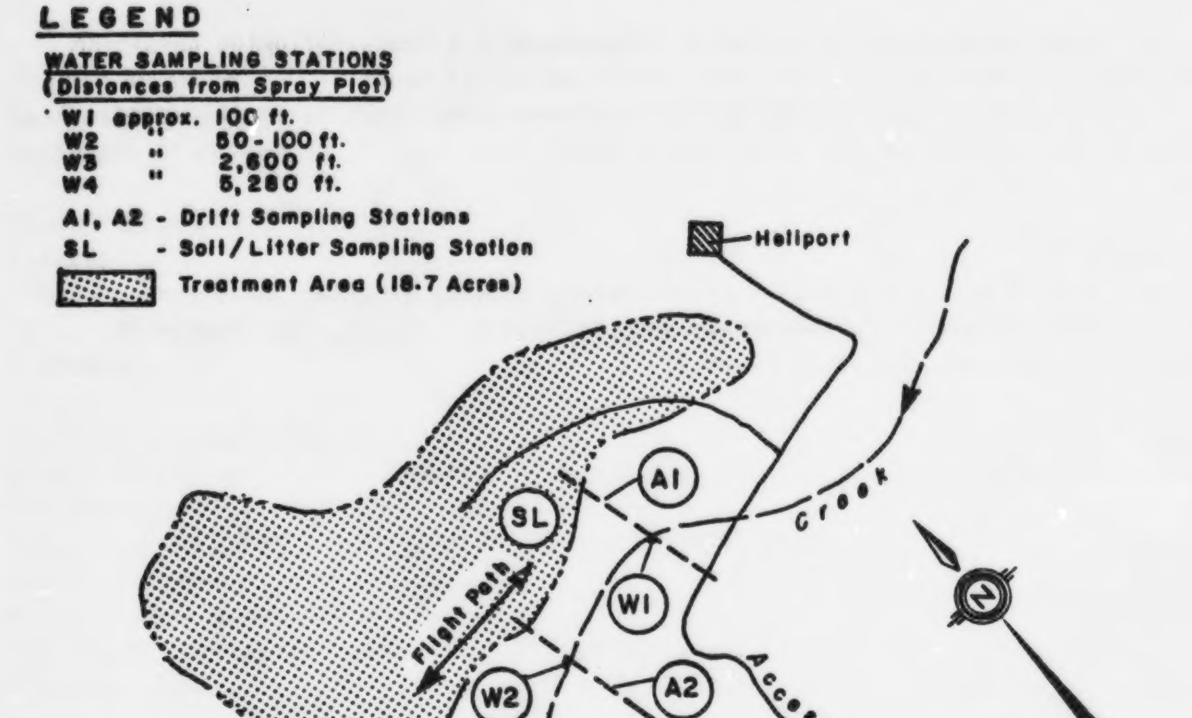

LEGEND
WATER SAMPLING STATIONS
(Distances from Spray Plot)
W1 approx. 100 ft.
W2 " 50 - 100 ft.
W3 " 2,600 ft.
W4 " 5,280 ft.
A1, A2 - Drift Sampling Stations
SL - Soil/Litter Sampling Station
Treatment Area (18.7 Acres)
Heliport
Creek
A1
SL
W1
Flight Path
W2
A2
Access Road
N
W3
Main Logging Road to SQUAMISH
W4
SQUAMISH RIVER

FIGURE 1-1 DIAGRAM OF SPRAY PLOT, SQUAMISH, B.C.

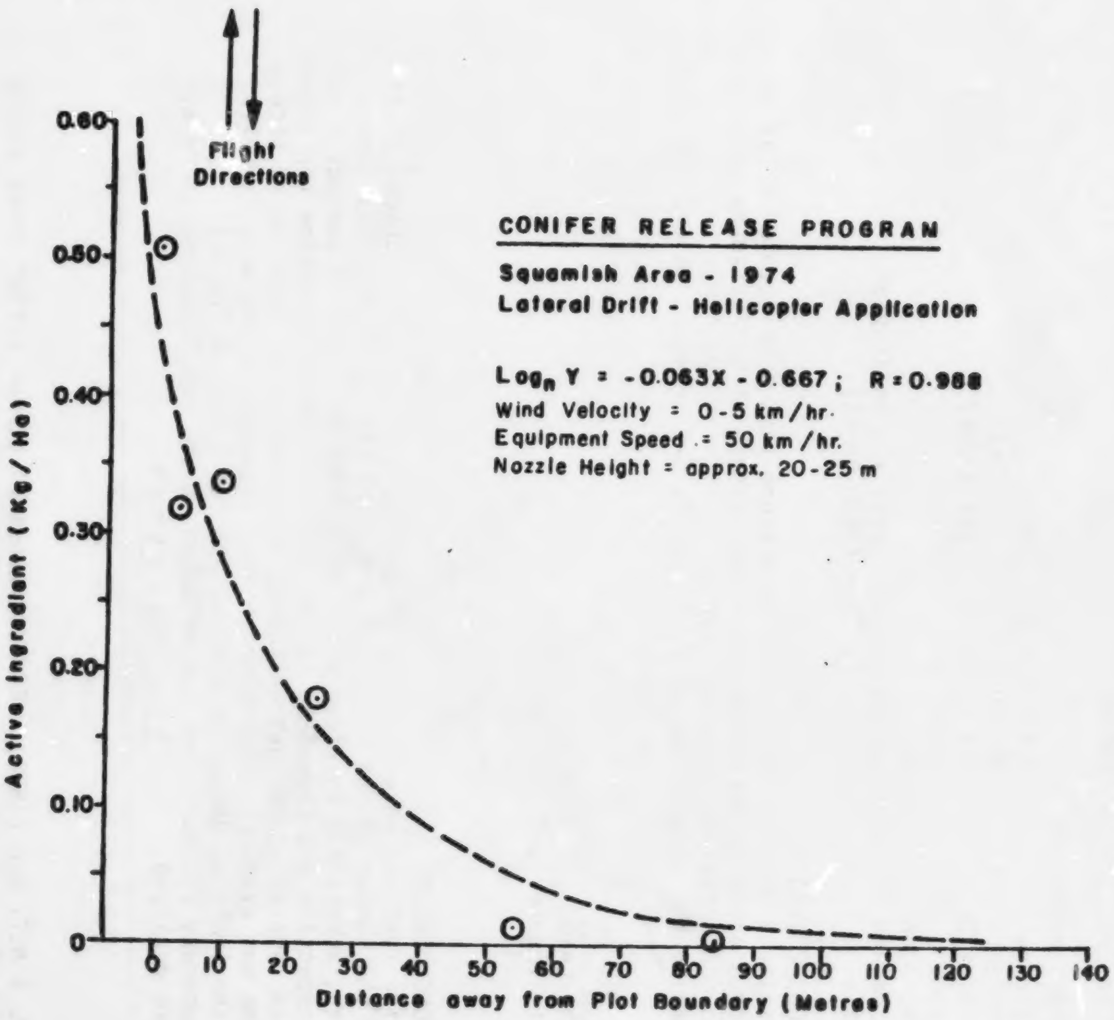


FIGURE 1-2 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No. : 2
Monitoring Agency : Environmental Protection Service
Proponent of Project : Weldwood Canada Limited

PROJECT DETAILS
Location : Toba Inlet, 160 km North of Vancouver
Purpose : Conifer release
Target species : Alder, Salmonberry
Treatment area : 104 ha

PESTICIDE USE INFORMATION
Name of Pesticide : 2,4-D/2,4,5-T (IOE)
Active Ingredient : As above
Rate of Application : 3.4 kg/ha (ie 3 lbs ai/ac)
Carrier/diluent : Diesel Oil
Drift Control Agent : NA
Application Method : Aerial dormant spray via helicopter
Treatment Date : April 14, 1975 (0630 hours)

MONITORING OBJECTIVES

1. To investigate drift of oil herbicide mixture from a helicopter spray in mountainous areas to determine the effectiveness of buffer zones in reducing contamination of water courses.
2. To determine the persistence of 2, 4-D/2, 4, 5-T residues in air and water.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to figures 1-3 and 1-4.

SUMMARY & CONCLUSIONS

Herbicide residues were detected on drift plates up to a distance of 45 meters from the border of the treatment plot. As the spray site was located in a remote area, accessible by plane only, no attempt was made to conduct a post treatment inspection and therefore it was not possible to determine the extent of streamside vegetation damage. Although herbicide drift occurred no stream contamination was evident. The chlorophenoxy residues in the water samples were below the limit of detection (ie, L1 ppb for 2,4,D, & 2,4,5-T).

Chlorophenoxy residues were not detected at the two locations where air samplers were deployed.

REFERENCE

Wilson, D.M. & M.T. Wan (1975). Effectiveness of stream buffer zones during aerial applications of chlorophenoxy and picloram herbicides. Environmental Protection Service. E.P.S. 5-PR-75-3.

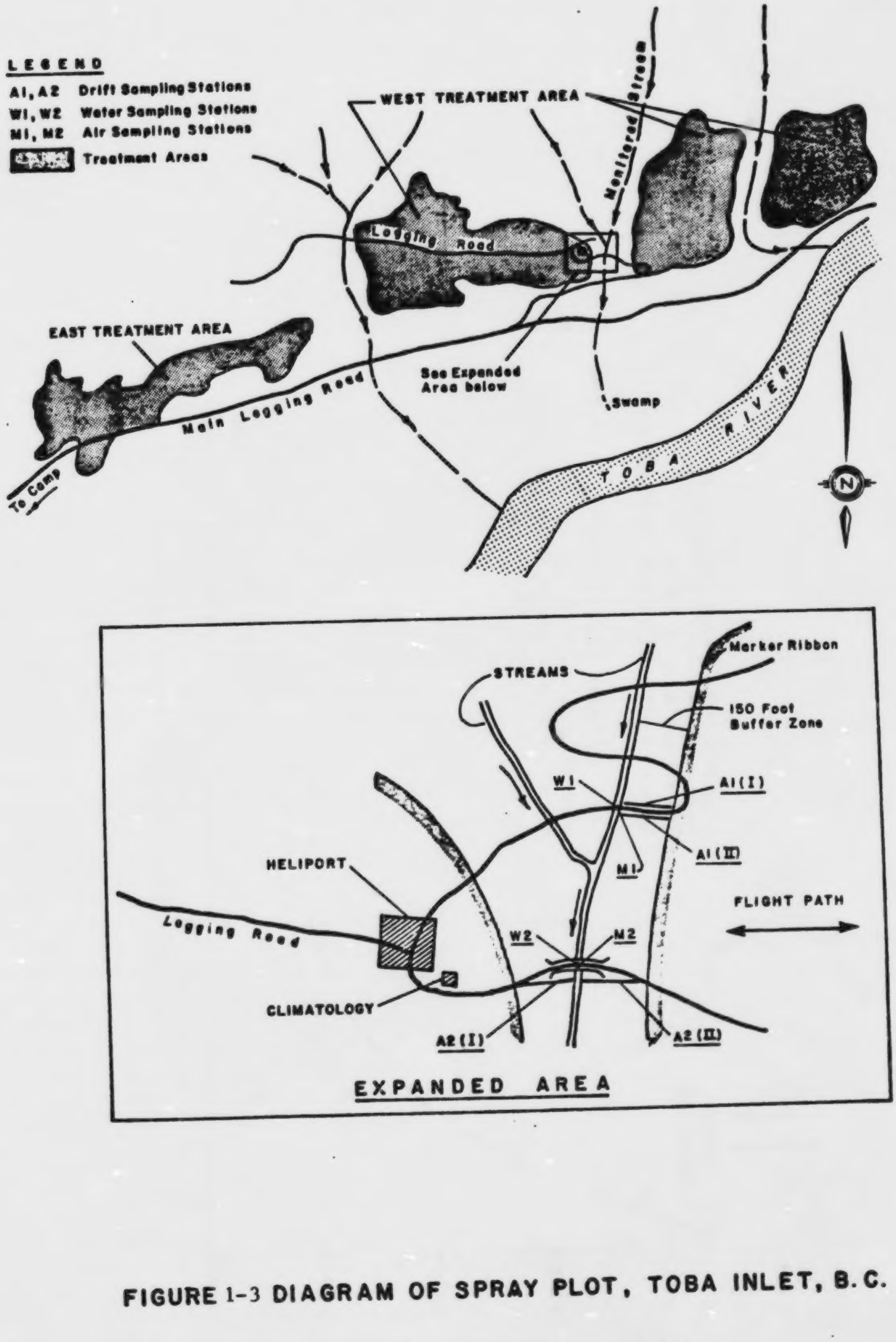

LEGEND
A1, A2 Drift Sampling Stations
W1, W2 Water Sampling Stations
M1, M2 Air Sampling Stations
Treatment Areas
WEST TREATMENT AREA
Monitored Stream
Logging Road
EAST TREATMENT AREA
Main Logging Road
To Camp
See Expanded Area below
Swamp
TOBA RIVER
N
STREAMS
Marker Ribbon
150 Foot Buffer Zone
W1
A1(I)
A1(II)
M1
HELIPORT
FLIGHT PATH
Logging Road
W2
M2
CLIMATOLOGY
A2(I)
A2(II)
EXPANDED AREA

FIGURE 1-3 DIAGRAM OF SPRAY PLOT, TOBA INLET, B.C.

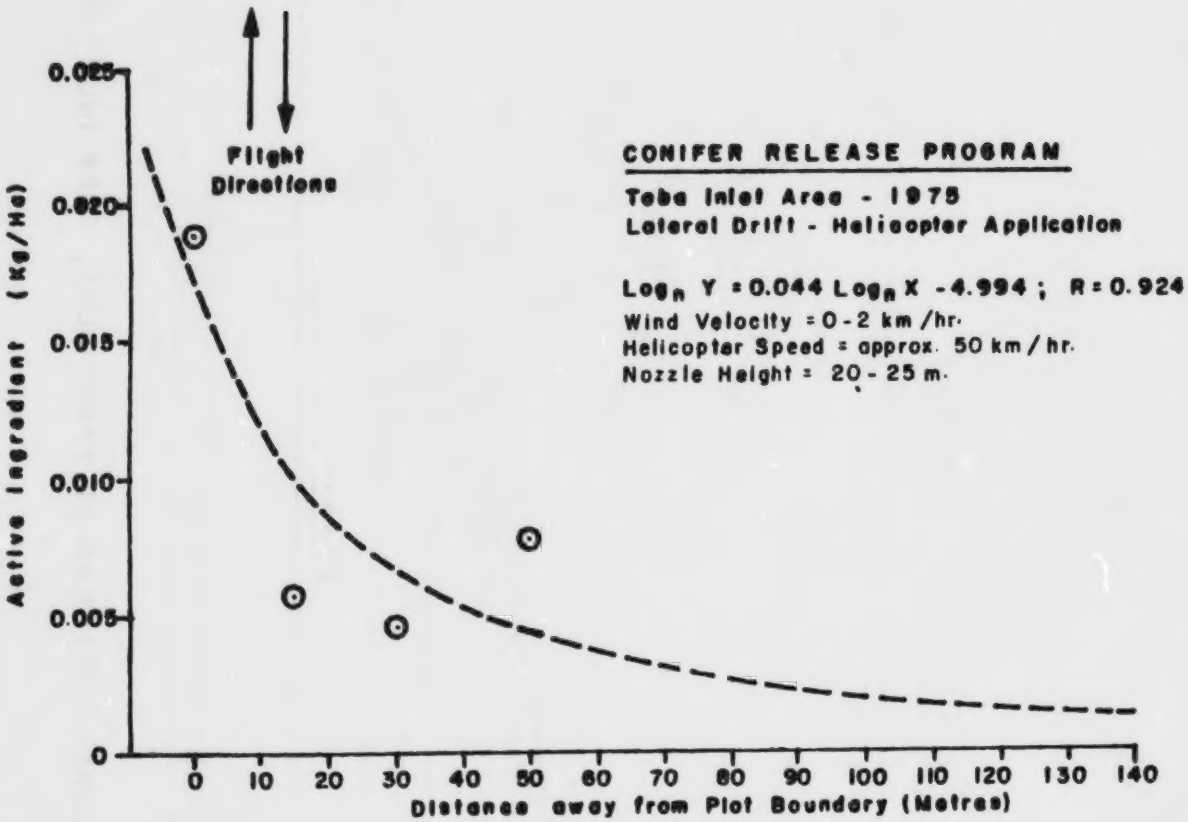


FIGURE 1-4 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No. : 3
Monitoring Agency : British Columbia Fish and Wildlife Branch
Proponent of Project : Rayonier Canada (B.C.) Limited

PROJECT DETAILS
Location : Holberg area
Purpose : Conifer release
Target species : Alder species
Treatment area : 109 ha

PESTICIDE USE INFORMATION
Name of Pesticide : 2,4-D/2,4,5-T (IOE)
Active Ingredient : As above
Rate of Application : 3.4 kg ai/ha (ie 3 lbs ai/ac)
Carrier/diluent : Diesel Oil
Drift Control Agent : NA
Application Method : Aerial foliar/dormant sprays via helicopter
Treatment Date : June, 1974; April, 1975

MONITORING OBJECTIVES

1. To investigate drift of herbicide-oil mixture from helicopter sprays.
2. To determine the effectiveness of buffer zones in reducing pesticide contamination of water courses.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 1-5,1-6, and 1-7.

SUMMARY & CONCLUSIONS

Herbicide residues were detected on drift plates up to a distance of 90 meters from the border of the treatment plot. Although this buffer zone reduced the amounts of aerially applied herbicides near waterbodies, it was inadequate to completely eliminate stream contamination, particularly when the flight path was at right angles to the water courses. As small quantities of residues were detected in the water up to 4 hours following spray application, it was recommended that the buffer zone should be increased.

A post-treatment inspection found that aerial herbiciding was ineffective against older plants higher than 4 meters.

REFERENCE

Ried, D.S., Mullett, R.G., Morley, R.C. (1977). Monitoring of an aerial herbicide treatment at Holberg, B.C. B.C. Ministry of Recreation and Conservation. Fisheries Tech. Circular No. 33.

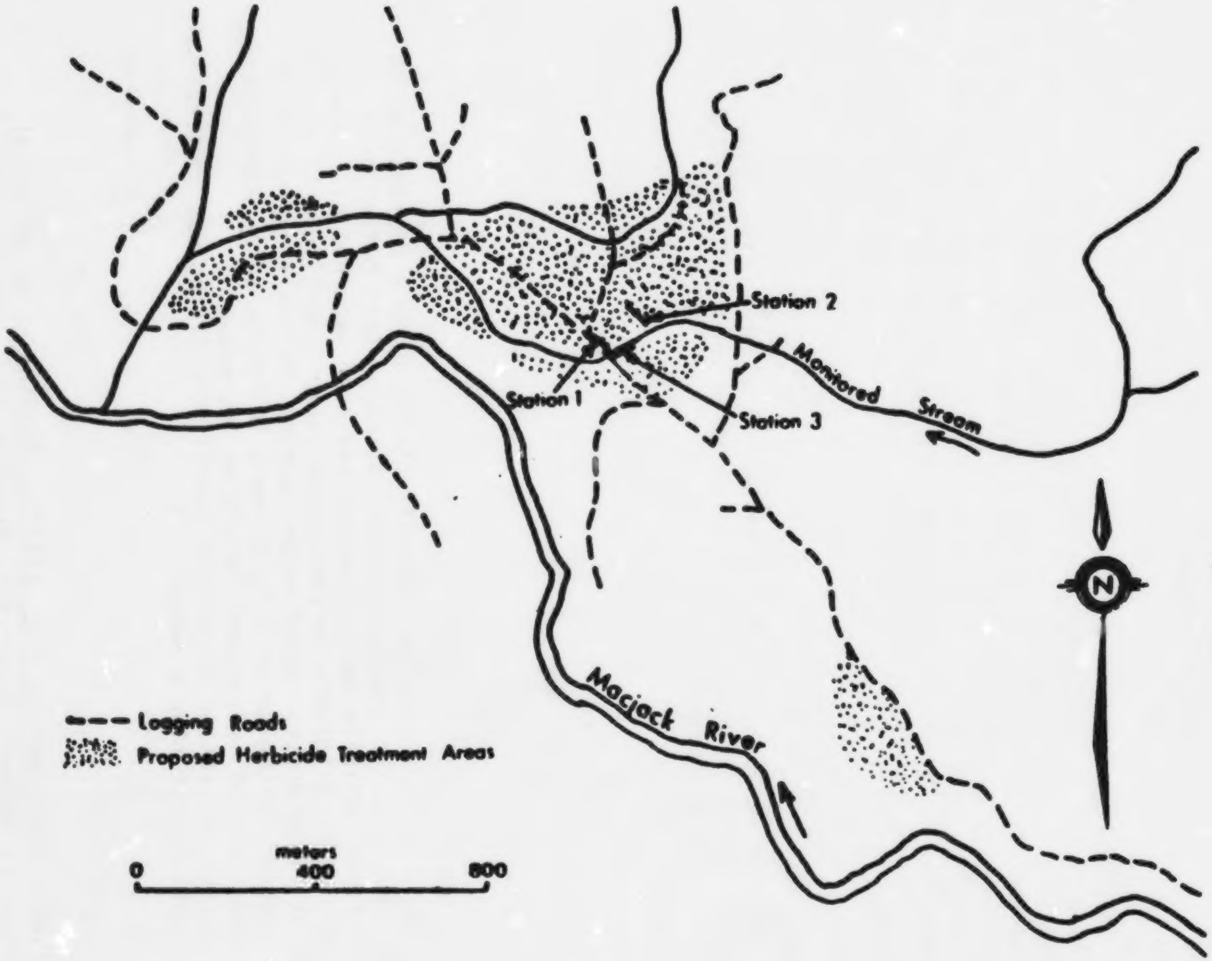

Station 2
Monitored Stream
Station 1
Station 3
N
Macjack River
Logging Roads
Proposed Herbicide Treatment Areas
meters
0
400
800

FIGURE 1-5 HERBICIDE TREATMENT SITE I (Macjack River)

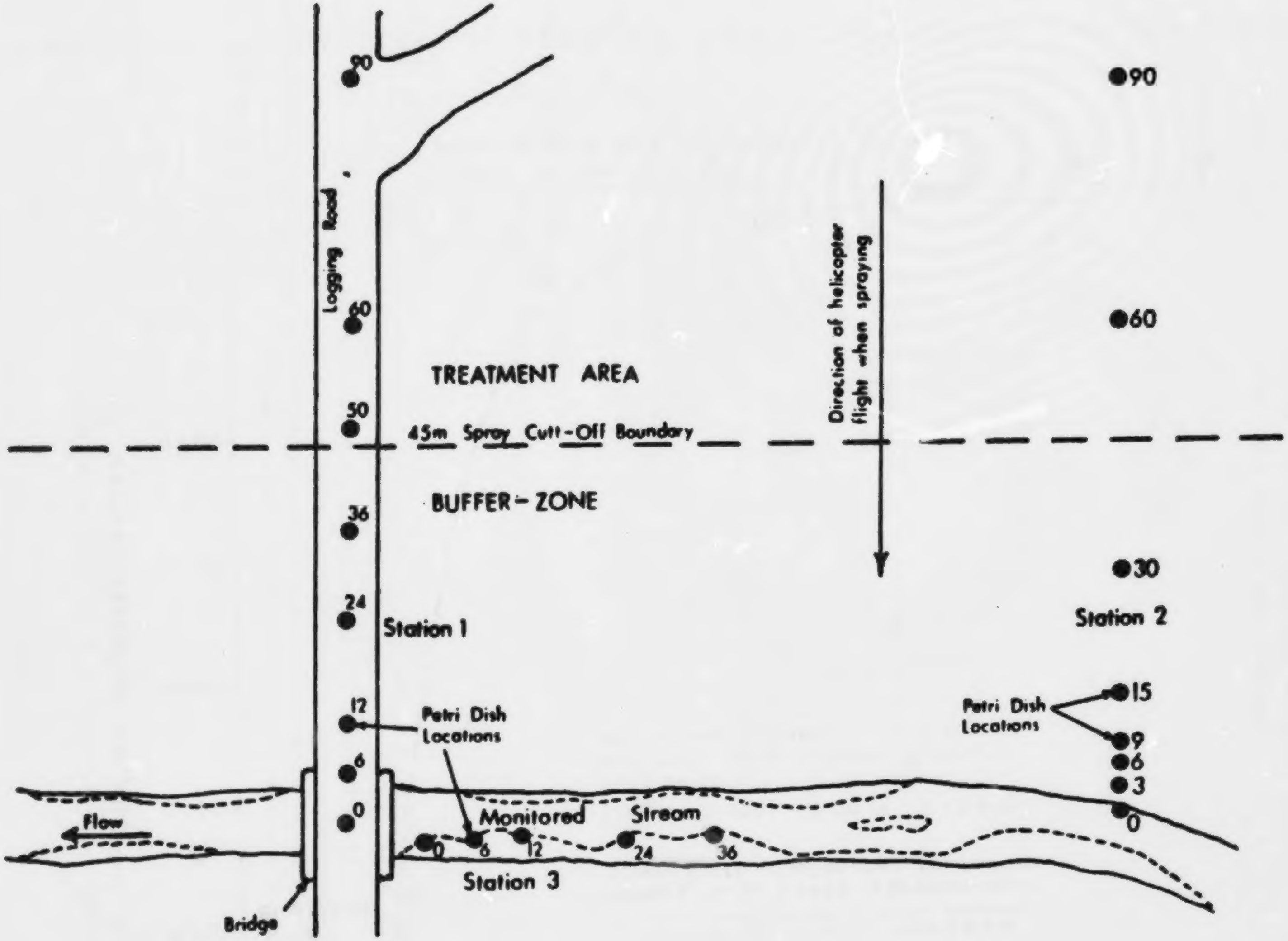

Logging Road
90
60
50
36
24
12
6
0
TREATMENT AREA
45m Spray Cutt-Off Boundary
BUFFER-ZONE
Station 1
Petri Dish Locations
Direction of helicopter flight when spraying
90
60
30
Station 2
Petri Dish Locations
15
9
6
3
0
Flow
Monitored Stream
0
6
12
24
36
Station 3
Bridge

FIGURE 1-6 SITE I FOR HERBICIDE MONITORING NEAR MacJACK RIVER

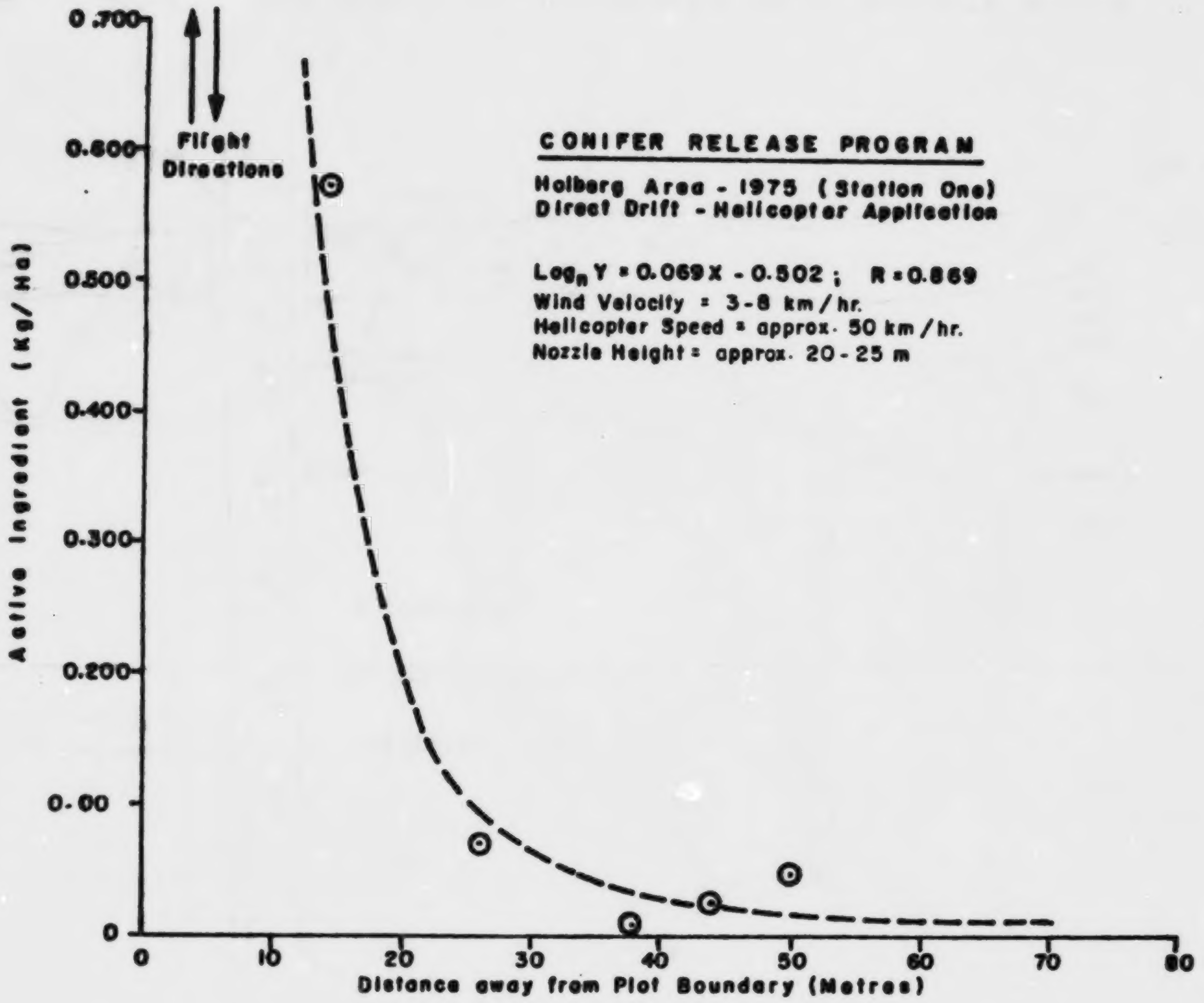


FIGURE 1-7 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No.	:	4
Monitoring Agency	:	British Columbia Fish and Wildlife Branch
Proponent of Project	:	Timberland Development Company

PROJECT DETAILS

Location	:	Toba Inlet area
Purpose	:	Conifer release
Target species	:	Alder species
Treatment area	:	100 ha

PESTICIDE USE INFORMATION

Name of Pesticide	:	2,4-D amine
Active Ingredient	:	As above
Rate of Application	:	2.8 kg ai/ha (ie 2.5 lbs ai/ac)
Carrier/diluent	:	Water
Drift Control Agent	:	NA
Application Method	:	Aerial foliar spray via helicopter
Treatment Date	:	June, 24, 1974

MONITORING OBJECTIVES

1. To investigate spray drift of herbicide-water mixture beyond treatment boundaries.
2. To determine the effectiveness of stream buffer zones in reducing contamination of water courses.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 1-8,1-9,1-10,1-11 and 1-12.

SUMMARY & CONCLUSIONS

Herbicide contamination of stream water by aerially applied 2,4-D occurred when designated buffer zones were not adhered to (up to 1.77 ppm of 2,4-D). Small quantities of herbicide residues (0.061 ppm) were detected in the stream water beyond 96 hours following the spray application. This study indicated that adherence of stream buffer zones can reduce the presence of aerially applied herbicides near a stream. Herbicide drift beyond treatment boundaries was minimal.

REFERENCE

Morley, R.L. and D.S. Reid (1975). Monitoring of an aerial Herbicide Treatment at Toba Inlet, B.C. B.C. Ministry of Recreation and Conservation. Monitoring Study No. 1.

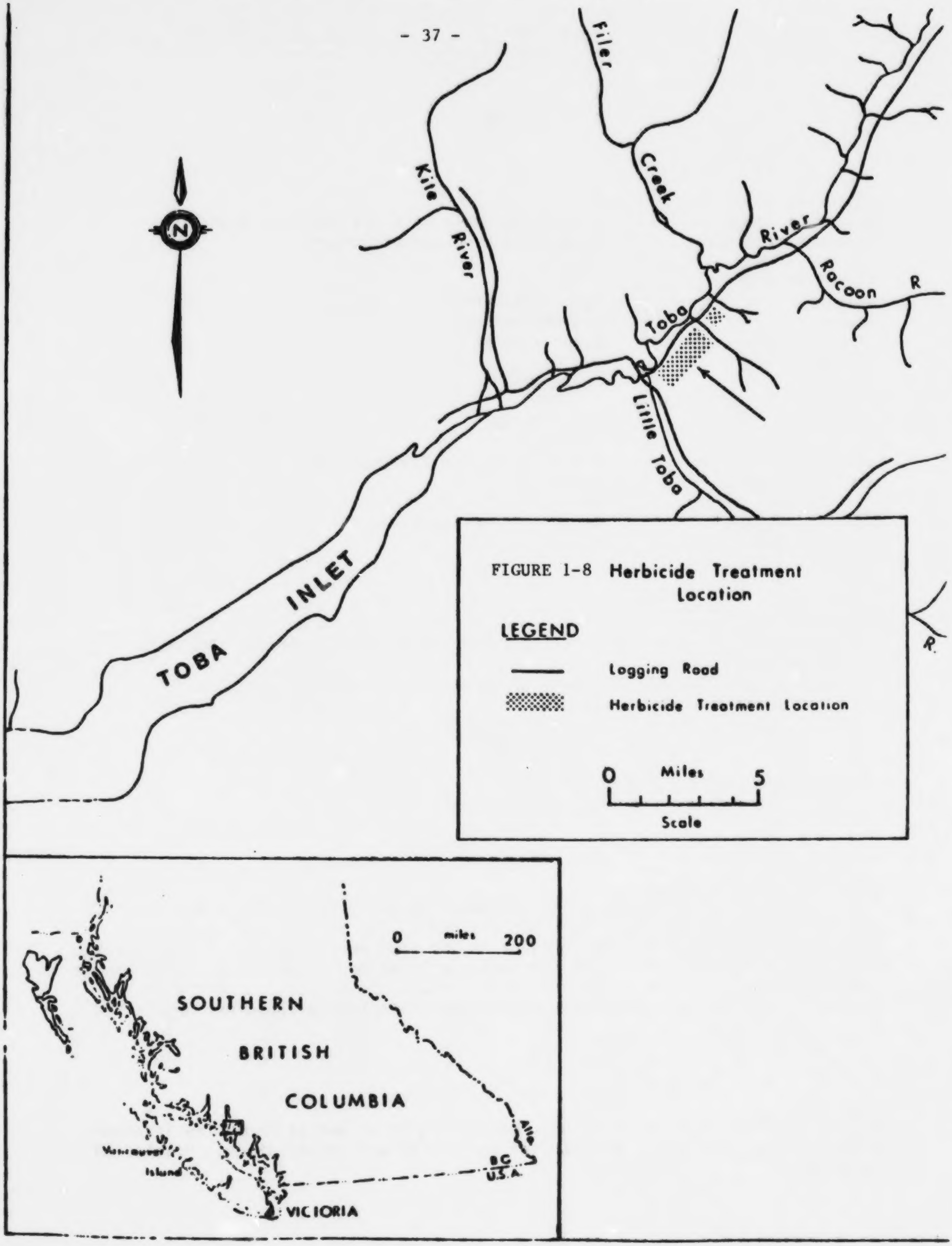


FIGURE 1-8 Herbicide Treatment Location

Filer
Creek
Kile
River
River
Racoon R
Toba
Little Toba
TOBA INLET
N
R.
LEGEND
Logging Road
Herbicide Treatment Location
0 Miles 5
Scale
SOUTHERN BRITISH COLUMBIA
0 miles 200
Vancouver Island
VICTORIA
BC
U.S.A.
Alta.

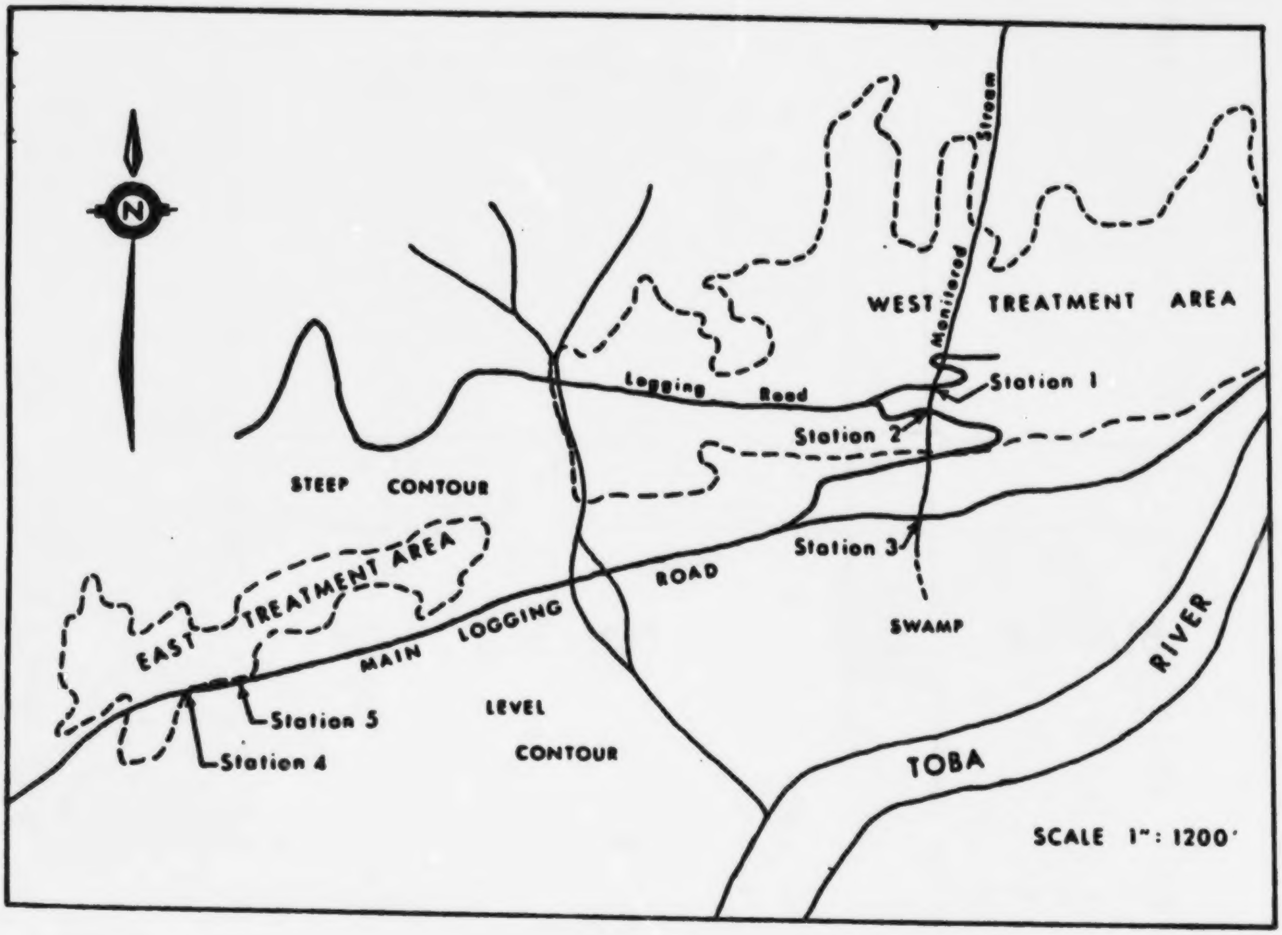

N
WEST TREATMENT AREA
Monitored Stream
Station 1
Logging Road
Station 2
STEEP CONTOUR
EAST TREATMENT AREA
Station 3
MAIN LOGGING ROAD
SWAMP
Station 5
Station 4
LEVEL CONTOUR
TOBA RIVER
SCALE 1": 1200'

Figure 1-9 Herbicide Treatment Areas at Toba Inlet, B.C.

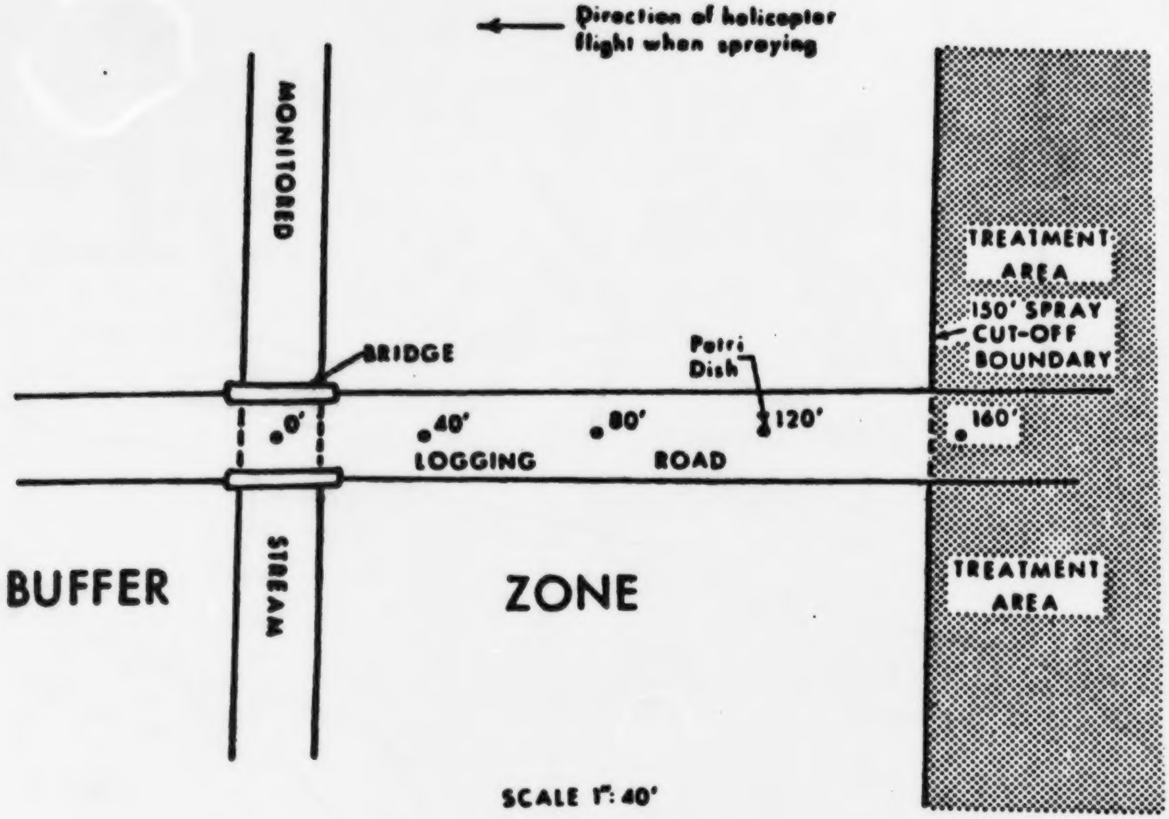

Direction of helicopter flight when spraying
MONITORED
STREAM
BRIDGE
Petri Dish
0'
40'
80'
120'
160'
LOGGING
ROAD
BUFFER
ZONE
TREATMENT AREA
150' SPRAY CUT-OFF BOUNDARY
TREATMENT AREA
SCALE 1": 40'

Figure 1-10 Diagram of petri dish layout for monitoring stream buffer-zone. (stations 1 and 2).

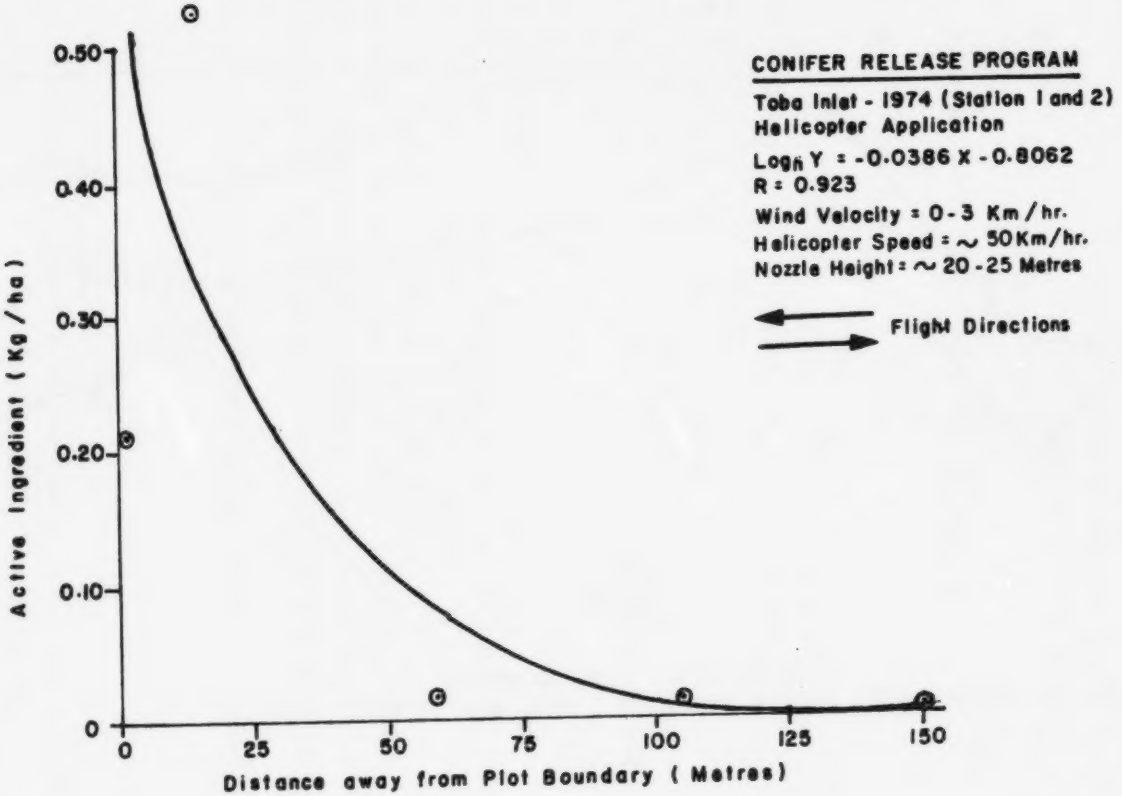


FIGURE 1-11 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

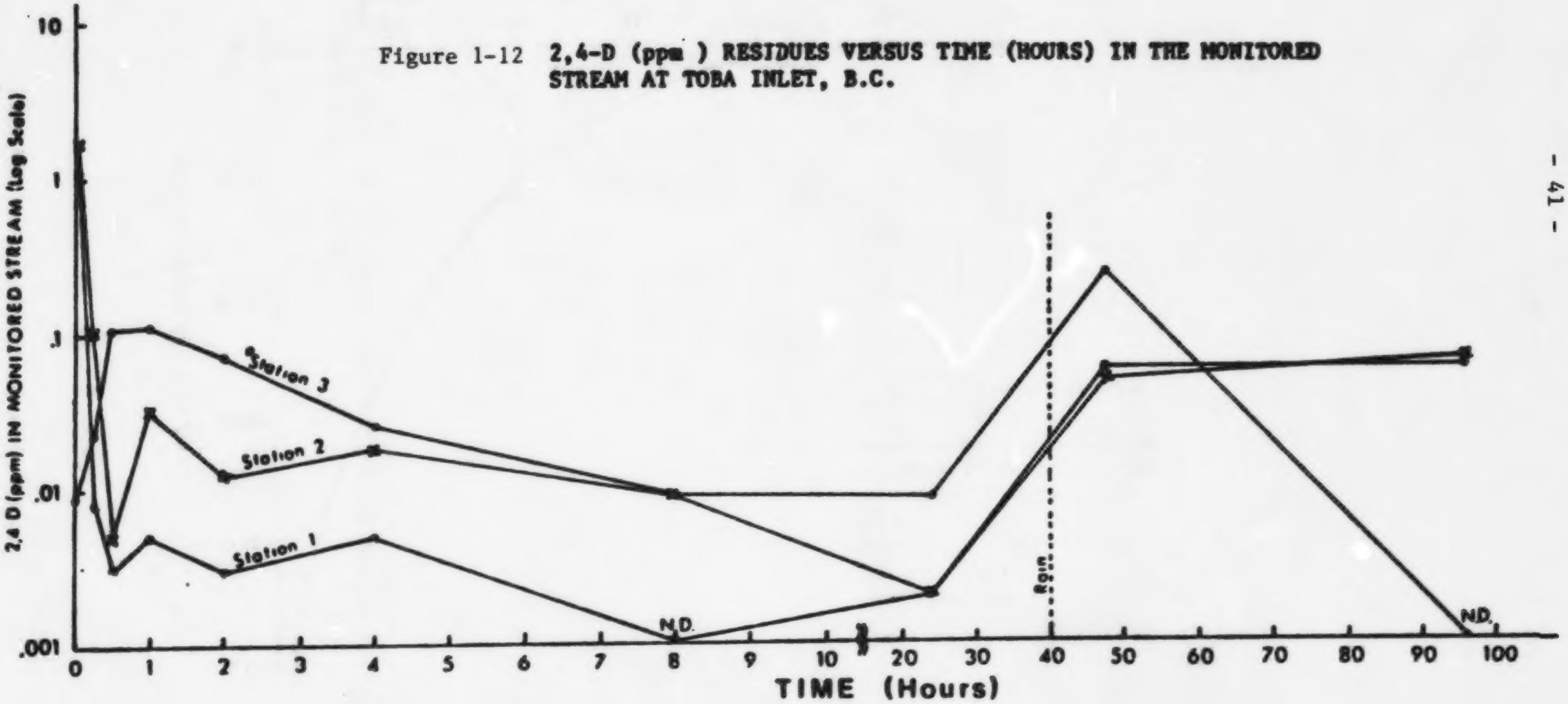


Figure 1-12 **2,4-D (ppm) RESIDUES VERSUS TIME (HOURS) IN THE MONITORED STREAM AT TOBA INLET, B.C.**

N.D. Not detectable
***** Station 3 situated outside lower boundary of treatment area.

Monitoring Study No. : 5
Monitoring Agency : Environmental Protection Service, Department of Fisheries and Oceans, B.C. Fish and Wildlife Branch
Proponent of Project : (1) University of British Columbia
(2) Cattermole Timber Company

PROJECT DETAILS

Location : (1) UBC Research Forest, Maple Ridge
(2) Bench Road Rehabilitation area, Chilliwack
Purpose : Brown and Burn
Target species : Alder, Maple
Treatment area : (1) 14.5 ha (2) 110 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Roundup
Active Ingredient : Glyphosate
Rate of Application : (1) 3 kg/ha (2) 0-3 kg/ha
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Foliar application via helicopter
Treatment Date : (1) June 18/1982 (2) June 25/1982

MONITORING OBJECTIVES

1. To investigate glyphosate contamination in a creek protected and one that is unprotected by a buffer zone during aerial forestry operations.
2. To compare glyphosate concentrations in runoff water in a creek protected and one that is not protected by a buffer zone.
3. To monitor glyphosate concentrations in sediment deposited via recent runoff in a creek protected and one that is not protected by a buffer zone, and
4. To observe the impact of sublethal concentrations of glyphosate in runoff water on fish.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 1-13 and 1-14 and Tables 1-1, 1-2, 1-3 and 1-4.

SUMMARY & CONCLUSIONS

These studies showed that glyphosate contamination in a creek protected by a buffer zone is much lower than one that is not protected by a buffer zone during aerial forestry spray operations. These observations applied to both direct spray drift and contamination via runoff. As well, these studies showed that runoff transported glyphosate residues to creeks within the treated areas. Creeks protected by a buffer zone (50-110m) contained much lower concentrations of glyphosate than creeks that were not protected by a buffer zone. In addition, glyphosate and its principal metabolite, amino methylphosphonic acid were found in the newly deposited sediments in the monitored creeks.

No signs of distress were noted in caged rainbow trout exposed to sublethal concentrations of glyphosate (i.e. 5 to 100 ppb) for a period of 60-70 days.

REFERENCE

Wan, M.T. (1982). Stream Contamination and Impact of Glyphosate on Fish During and Following Aerial Operations in Coastal Forest Areas of British Columbia. EPS Memo Report. October, 1982.

TABLE 1-1 CONCENTRATION OF GLYPHOSATE IN CREEK WATER (no buffer zone)
UBC FOREST, MAPLE RIDGE

TIME (days)	GLYPHOSATE (ppb)	AMPA (ppb)
Prespray (control creek)	< 5	-
Prespray (treated creek)	< 5	-
0.04 (1 hr post spray)	20	-
0.12 (2-3 hr)	23	-
1	5	-
2	< 5	-
3	< 5	-
8 (rain, runoff)	100 (creek)	-
	63 (pond)	-
14	6	-
18 (rain, runoff)	5	-
20	< 5	-
28	< 5	< 5
56	< 5	< 5
56 (control creek)	< 5	< 5
90	< 5	< 5

Limit of detection: 5 ppb in water
100 ppb in sediment

AMPA - Aminomethyl phosphonic acid, the main metabolite of glyphosate

TABLE 1-2 CONCENTRATION OF GLYPHOSATE IN CREEK SEDIMENT (no buffer zone)
UBC FOREST, MAPLE RIDGE

TIME (day)	GLYPHOSATE (ppm)	AMPA (ppm)
Prespray	< 0.1	< 0.1
1 (post spray)	< 0.1	< 0.1
8 (rain, runoff)	0.1	< 0.1
10	0.3	0.1
14 (rain, runoff)	0.1	< 0.1
20	0.4	0.2
40	0.2	0.2
57	< 0.1	< 0.1
90	0.2	0.2

TABLE 1-3 CONCENTRATION OF GLYPHOSATE IN CREEK WATER (50-100 m buffer zone), CHILLIWACK

TIME (days)	GLYPHOSATE (ppb)	AMPA (ppb)
Prespray (control creek)	< 5	< 5
Prespray (treated plot)	< 5	< 5
0.2 (post spray)	< 5	< 5
1	< 5	< 5
3	< 5	< 5
7 (rain, runoff)	13	< 5
21 (rain, runoff)	25	< 5
36	< 5	< 5
80	< 5	< 5

TABLE 1-4 CONCENTRATION OF GLYPHOSATE IN CREEK SEDIMENT (50-100 m buffer zone), CHILLIWACK

TIME (days)	GLYPHOSATE (ppm)	AMPA (ppm)
Prespray (control creek)	< 0.1	< 0.1
Prespray (treated plot)	< 0.1	< 0.1
1 (post spray)	< 0.1	< 0.1
7 (rain, runoff)	0.2	< 0.1
15 (rain, runoff)	0.1	0.1
28	< 0.1	< 0.1
75	< 0.1	< 0.1

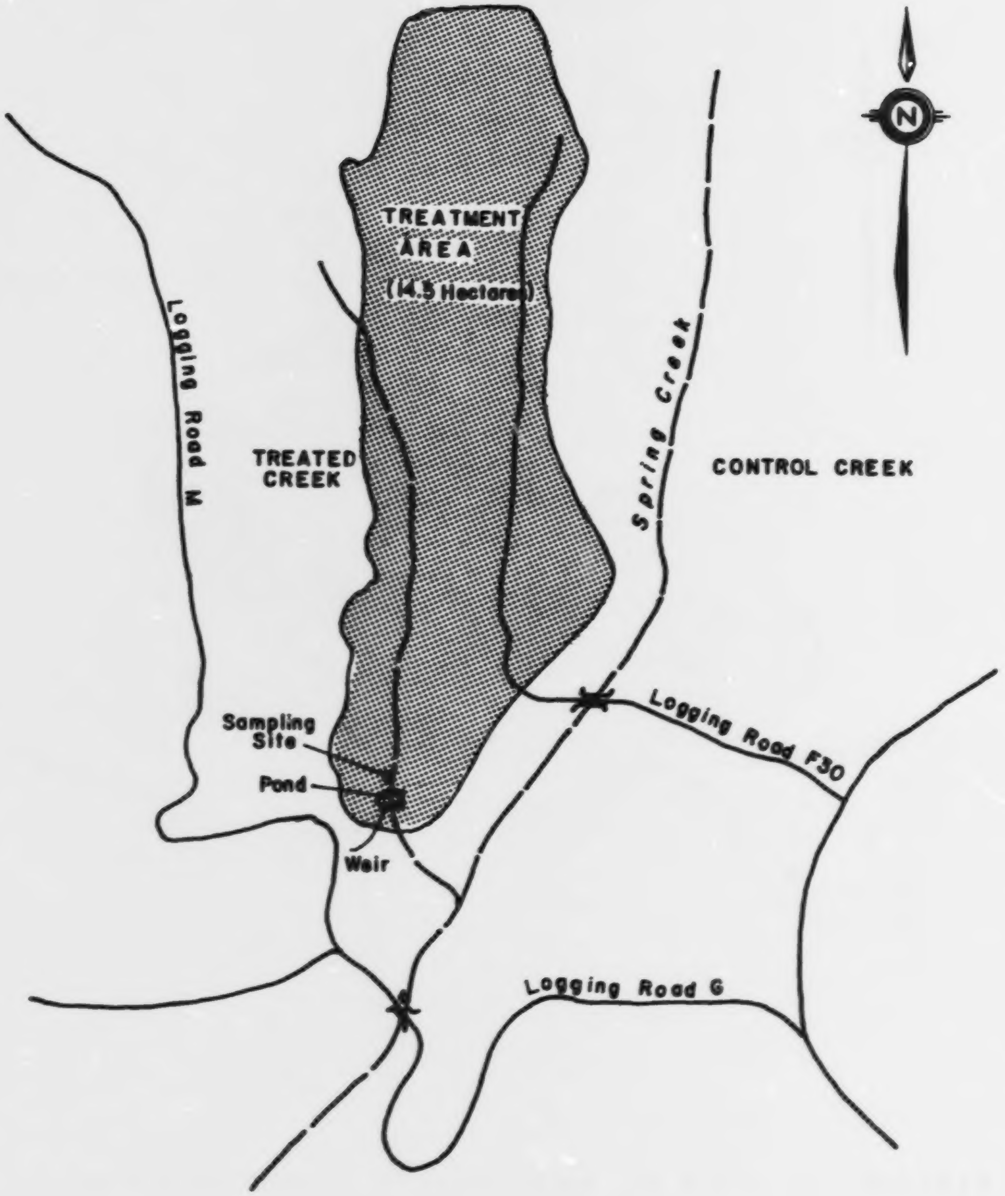

TREATMENT AREA
(14.5 Hectares)
Logging Road M
TREATED CREEK
Spring Creek
CONTROL CREEK
Sampling Site
Pond
Weir
Logging Road F30
Logging Road G
N

FIGURE 1-13 AERIAL GLYPHOSATE TREATMENT AREA-
UBC RESEARCH FOREST, MAPLE RIDGE

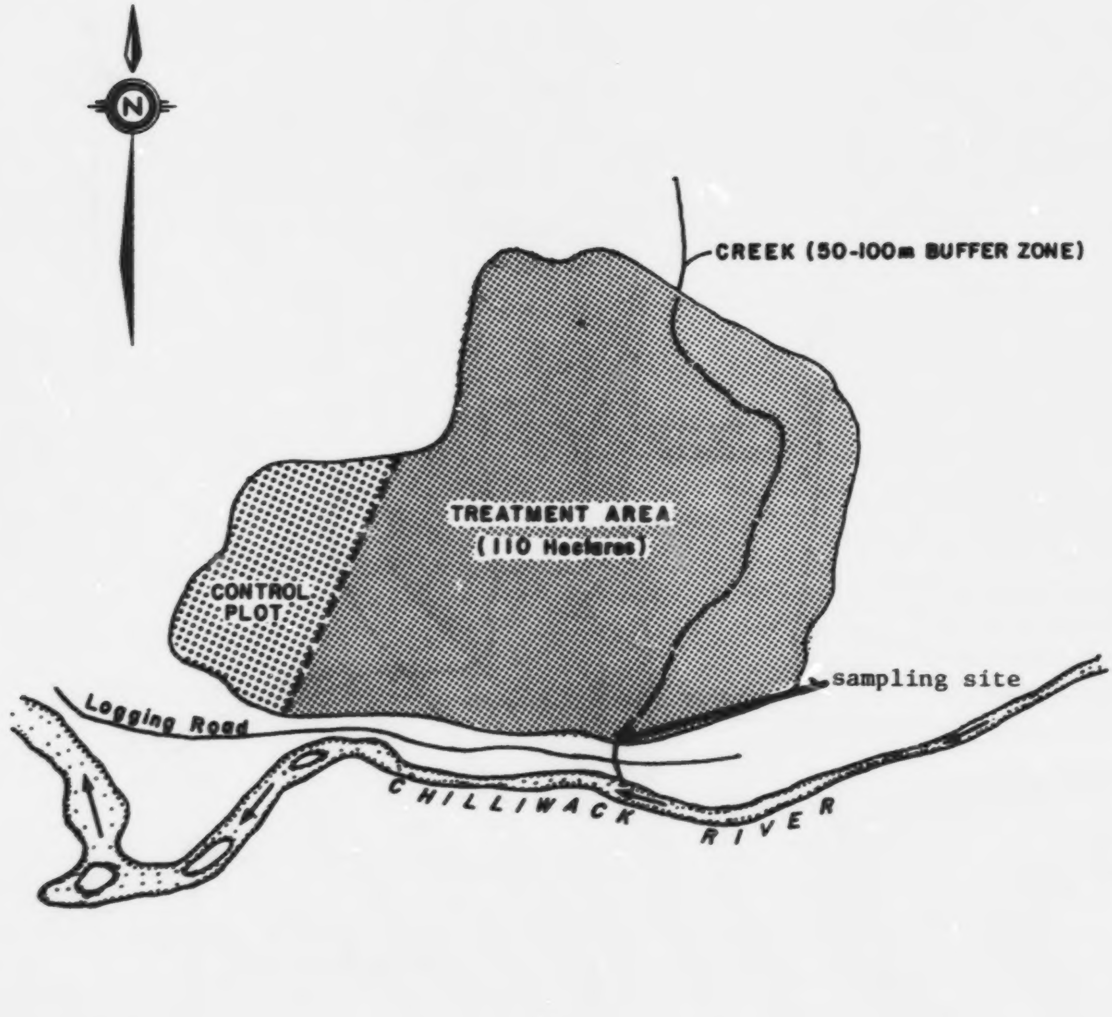

N
CREEK (50-100m BUFFER ZONE)
TREATMENT AREA
(110 Hectares)
CONTROL PLOT
sampling site
Logging Road
CHILLIWACK RIVER

FIGURE 1-14 AERIAL GLYPHOSATE TREATMENT AREA, BENCH ROAD AREA - CHILLIWACK, B.C.

APPENDIX II

RIGHTS-OF-WAY VEGETATION CONTROL PROGRAMMES

Monitoring Study No. : 6
Monitoring Agency : Environmental Protection Service
Proponent of Project : British Columbia Forest Products Ltd.

PROJECT DETAILS
Location : S.W. corner of Vancouver Island near Caycuse
Purpose : Right-of-way Brush Control
Target species : Alder
Treatment area : 2 ha

PESTICIDE USE INFORMATION
Name of Pesticide : 2,4-D/2,4,5-T amine and ester formulations
Active Ingredient : As above
Rate of Application : 0 to 4.5 kg ai/ha (ie 0 to 4 lbs ai/ac)
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Truck mounted mist blower
Treatment Date : 1/ August; 1973, 2/ April; 1974 3/ June; 1974

MONITORING OBJECTIVES

1. To determine the effectiveness of chlorophenoxy formulations at different rates of application during different seasons of the year.
2. To evaluate the drift of herbicide/water mixtures from a truck mounted mist blower.
3. To assess the persistence of herbicide residues in soil and water, and
4. To investigate the impact of chlorophenoxy herbicides on non-target organisms such as birds, fish, terrestrial arthropods, and wildlife.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 2-1, 2-2, 2-3, 2-4, and 2-5.

SUMMARY & CONCLUSIONS

These studies demonstrated that amine and ester formulations of 2,4-D and 2,4,5-T were equally effective for roadside alder control. The minimum amount of effective chemical for summer foliar treatment was 1.1-1.3 kg. active material per hectare. Two to four weeks were required for the chlorophenoxy compounds to produce their toxic effects on alder.

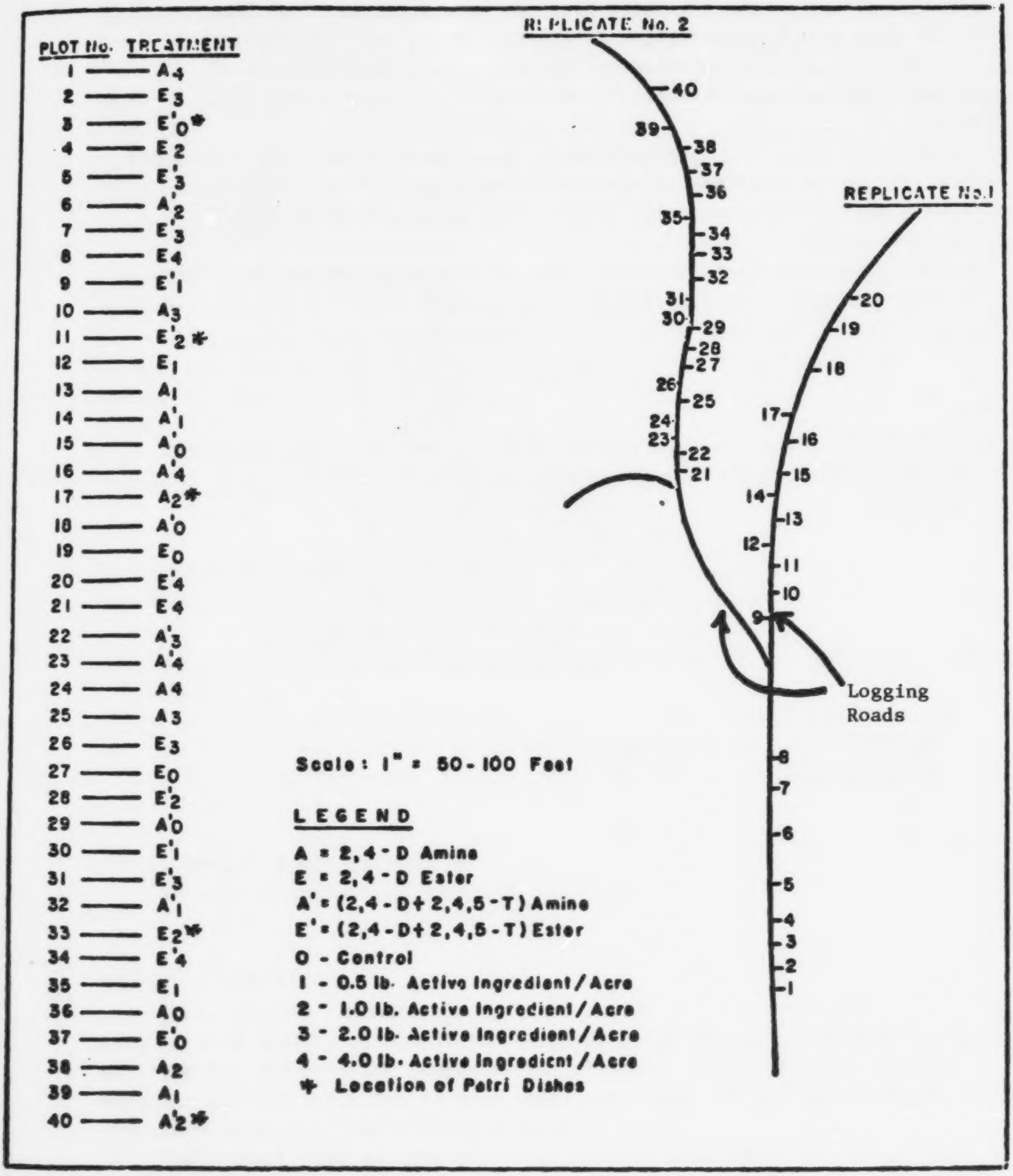
Small quantities of chlorophenoxy residues were found in the air at a distance of 6 metres from the point of application. Although 99 percent of the residues in the forest litter disappeared within one week following application, residues in the treated vegetation were detected after leaf excision for more than 50 weeks after treatment. There was indication that some of these residues were released to the soil. Only trace amounts of chlorophenoxy residues were detected in ditch water 1-2 hours after spray application.

A significant reduction in population of non-target terrestrial arthropods was observed in foliar treatment plots soon after spray application. No decrease in number of birds near the experimental plots was noted after herbicide application.

Laboratory bioassay tests indicated that chlorophenoxy amines were less toxic to fish than the ester formulations. Long chain molecules appeared to be more toxic to coho fingerlings than short chain molecules.

REFERENCE

Wan, M.T.K. (1975). Impacts of Chlorophenoxy Herbicides on a Coastal Forest Environment of British Columbia. Environmental Protection Service. E.P.S. 5-PR-75-4.



PLOT No.	TREATMENT
1	A_4
2	E_3
3	E'_0*
4	E_2
5	E'_3
6	A'_2
7	E'_3
8	E_4
9	E'_1
10	A_3
11	E'_2*
12	E_1
13	A_1
14	A'_1
15	A'_0
16	A'_4
17	A_2*
18	A'_0
19	E_0
20	E'_4
21	E_4
22	A'_3
23	A'_4
24	A_4
25	A_3
26	E_3
27	E_0
28	E'_2
29	A'_0
30	E'_1
31	E'_3
32	A'_1
33	E_2*
34	E'_4
35	E_1
36	A_0
37	E'_0
38	A_2
39	A_1
40	A'_2*

REPLICATE No. 2
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
REPLICATE No. 1
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Logging Roads

Scale: 1" = 50-100 Feet

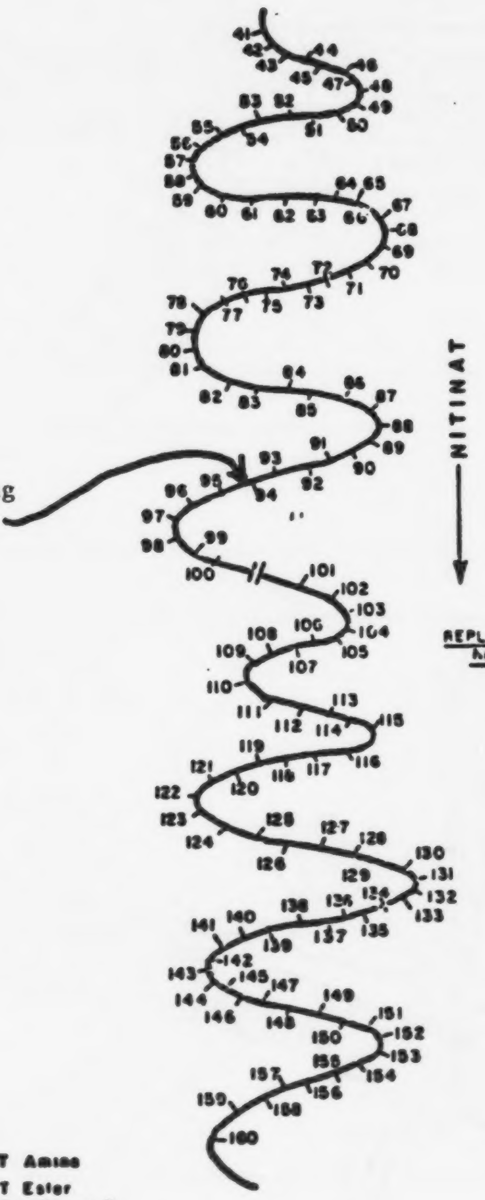
LEGEND

A = 2,4-D Amine
E = 2,4-D Ester
A' = (2,4-D + 2,4,5-T) Amine
E' = (2,4-D + 2,4,5-T) Ester
0 - Control
1 - 0.5 lb. Active Ingredient/Acre
2 - 1.0 lb. Active Ingredient/Acre
3 - 2.0 lb. Active Ingredient/Acre
4 - 4.0 lb. Active Ingredient/Acre
* Location of Petri Dishes

FIGURE 2-1 PLOT LAYOUT OF EXPERIMENT NO. 1 (NIXON CREEK)

EXPERIMENT No. 2

PLOT No.	TREATMENT	
41	E_1	REPLICATE No 1
42	E'_0 §	
43	E'_4	
44	E'_0	
45	E_2 §	
46	E_3	
47	A_4	
48	T_0	
49	T'_1	
50	A'_2 §	
51	A_0	
52	T_1	
53	T'_3	
54	A'_1	
55	E_4	
56	A_3	
57	T'_2 §	
58	T'_0	
59	T_4	
60	A'_3	
61	T'_4	
62	E'_2 §	
63	E'_1	
64	T_2 §	
65	A_2 §	
66	T_3	
67	E'_3	
68	A_1	
69	E_0	
70	A'_4	
71	E_2	REPLICATE No 2
72	T_0	
73	T'_1	
74	E'_2	
75	A_2	
76	E_1	
77	A'_0	
78	A'_2	
79	T_4	
80	A_0	
81	T'_2	
82	A_3	
83	A'_1	
84	E_3	
85	T'_3	
86	E_4	
87	T_2	
88	E'_0	
89	E'_1	
90	T'_0	
91	A_1	
92	T'_4	
93	E_4	
94	A_4	
95	E'_3	
96	A'_3	
97	T_1	
98	T_3	
99	E_0	
100	A'_4	


41
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145
146
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148
149
150
151
152
153
154
155
156
157
158
159
160
Logging Road
NITINAT

LEGEND

T = 2,4,5-T Amine

T' = 2,4,5-T Ester

A, A', E, E' - See Figure 2

§ Locations of Petri Dishes

Scale: 1" = 100 - 200 Feet

EXPERIMENT No. 3

	PLOT No.	TREATMENT
REPLICATE No. 1	101	E'_1
	102	A'_4
	103	E_0
	104	E_4
	105	A'_2
	106	A_0
	107	T_1
	108	E'_3 §
	109	T_3 §
	110	A_4
	111	T'_3 §
	112	T_0
	113	A'_1
	114	T'_2
	115	E_2
	116	E'_4
	117	T_4
	118	A'_0 §
	119	E'_2
	120	E_1
	121	T'_0
	122	T_2
	123	A_1
	124	A'_3 §
	125	T_1
	126	T'_4
	127	E'_0
	128	E_3 §
	129	A_2
	130	A_3 §
REPLICATE No 2	131	E_2
	132	T_1
	133	A'_4
	134	E'_3
	135	A'_0
	136	A'_1
	137	A'_3
	138	A'_4
	139	T'_0
	140	E_4
	141	A_4
	142	E_0
	143	E_3
	144	E'_1
	145	A_0
	146	T_4
	147	A_3
	148	T_3
	149	A_2
	150	T'_3
	151	E'_2
	152	A_1
	153	T'_2
	154	T'_1
	155	E_1
	156	T'_4
	157	A'_2
	158	E'_0
	159	T_2
	160	T_0

FIGURE 2-2 PLOT LAYOUT OF EXPERIMENTS No. 2 AND No. 3 (NITINAT)

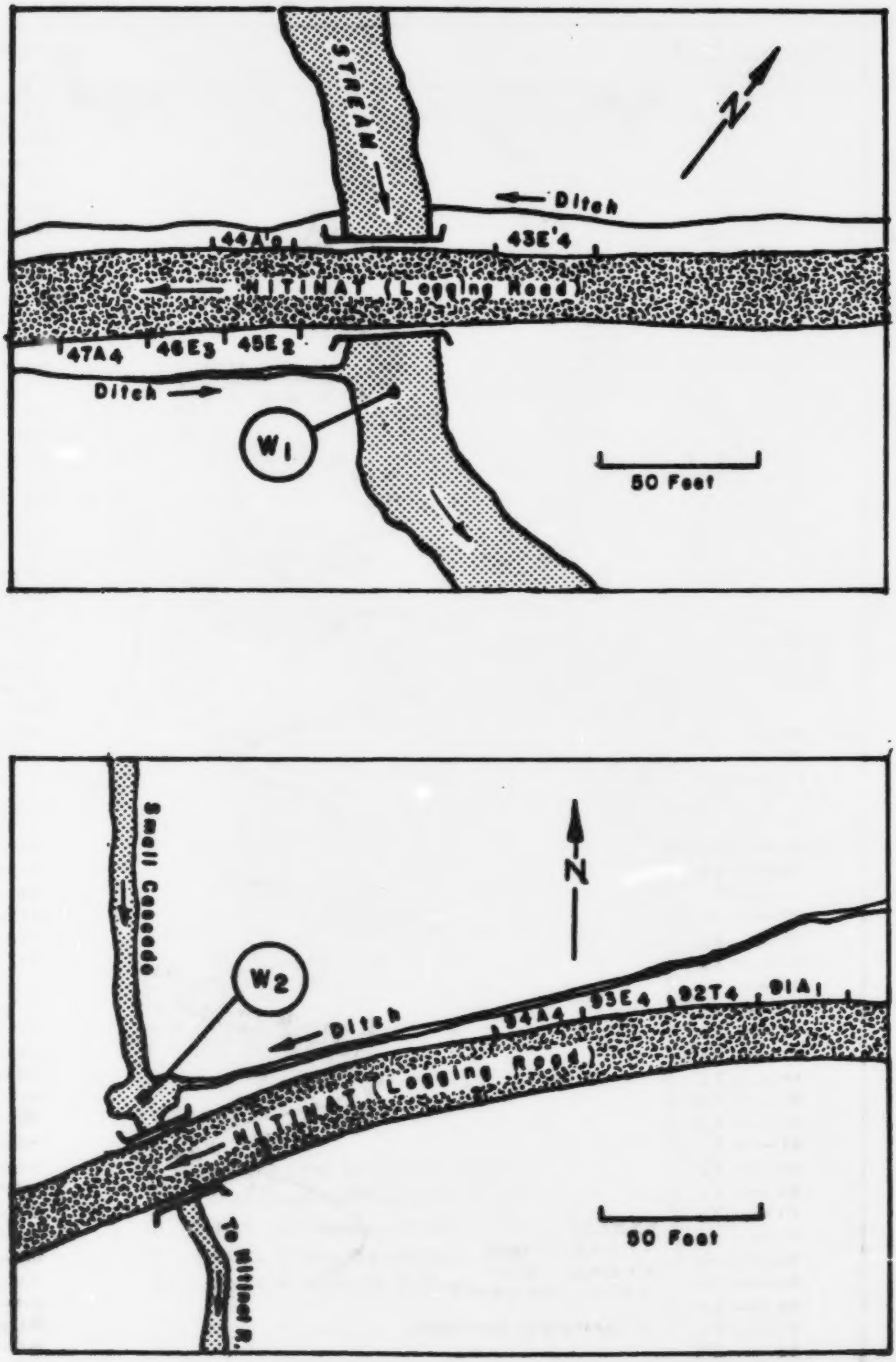

STREAM
N
Ditch
44A'2
43E'4
NITINAT (Logging Road)
47A4
46E3
45E2
Ditch
W1
50 Feet
Small Cascade
N
W2
Ditch
94A4
93E4
92T4
91A1
NITINAT (Logging Road)
To Nitinat R.
50 Feet

FIGURE 2-3 **DIAGRAMMATIC SKETCH OF WATER STATIONS W_1 AND W_2 (See Figure 8 for meaning of Plot Numbers)**

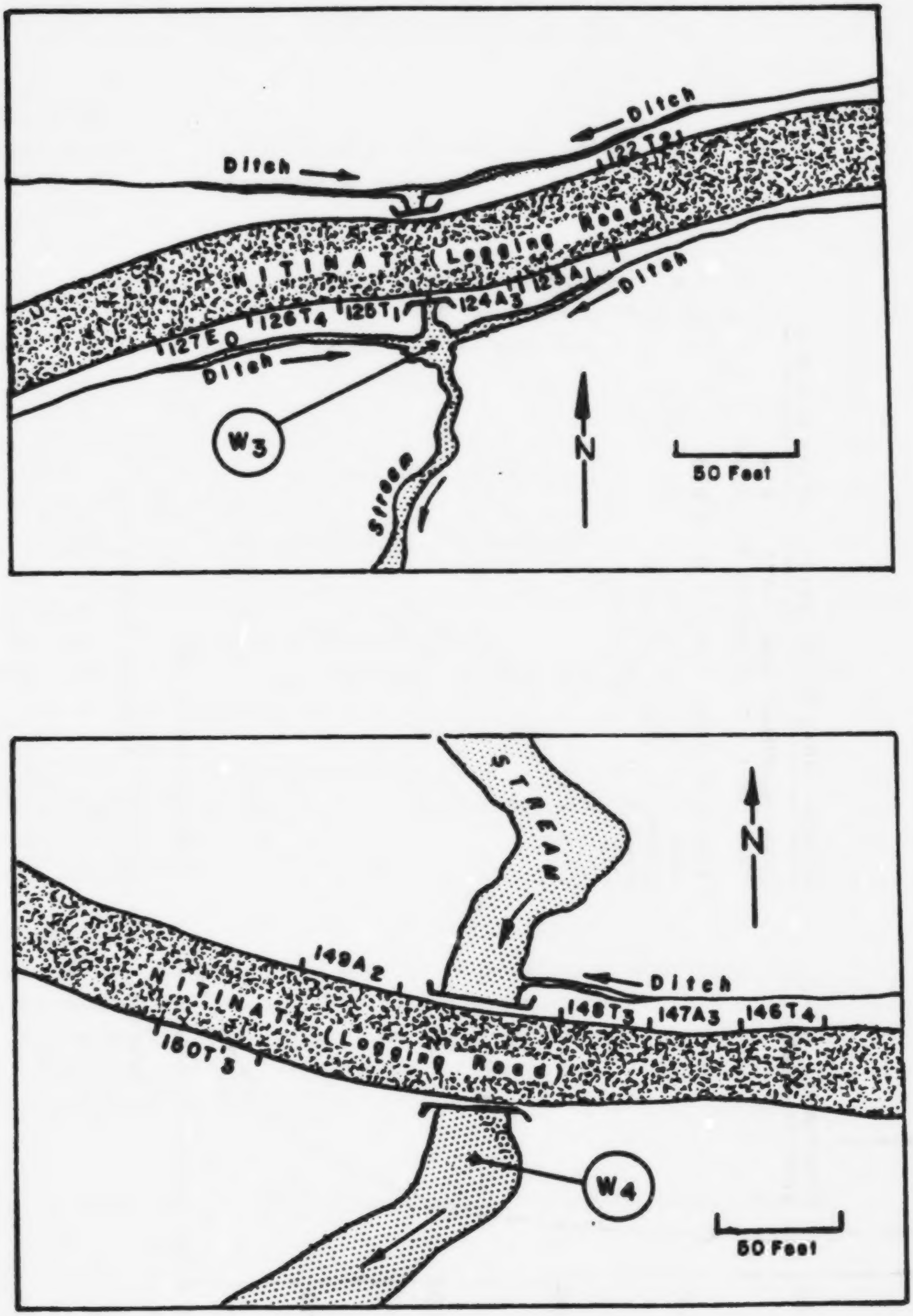

Ditch
Ditch
122 T2
NITINAT (Logging Road)
123A
Ditch
124A3
125T1
126T4
127E0
Ditch
W3
Stream
N
50 Feet
STREAM
N
149A2
Ditch
148T3
147A3
146T4
NITINAT (Logging Road)
150T'3
W4
50 Feet

FIGURE 2-4 **DIAGRAMMATIC SKETCH OF WATER STATIONS W_3 AND W_4 (See Figure 8 for meaning of Plot Numbers)**

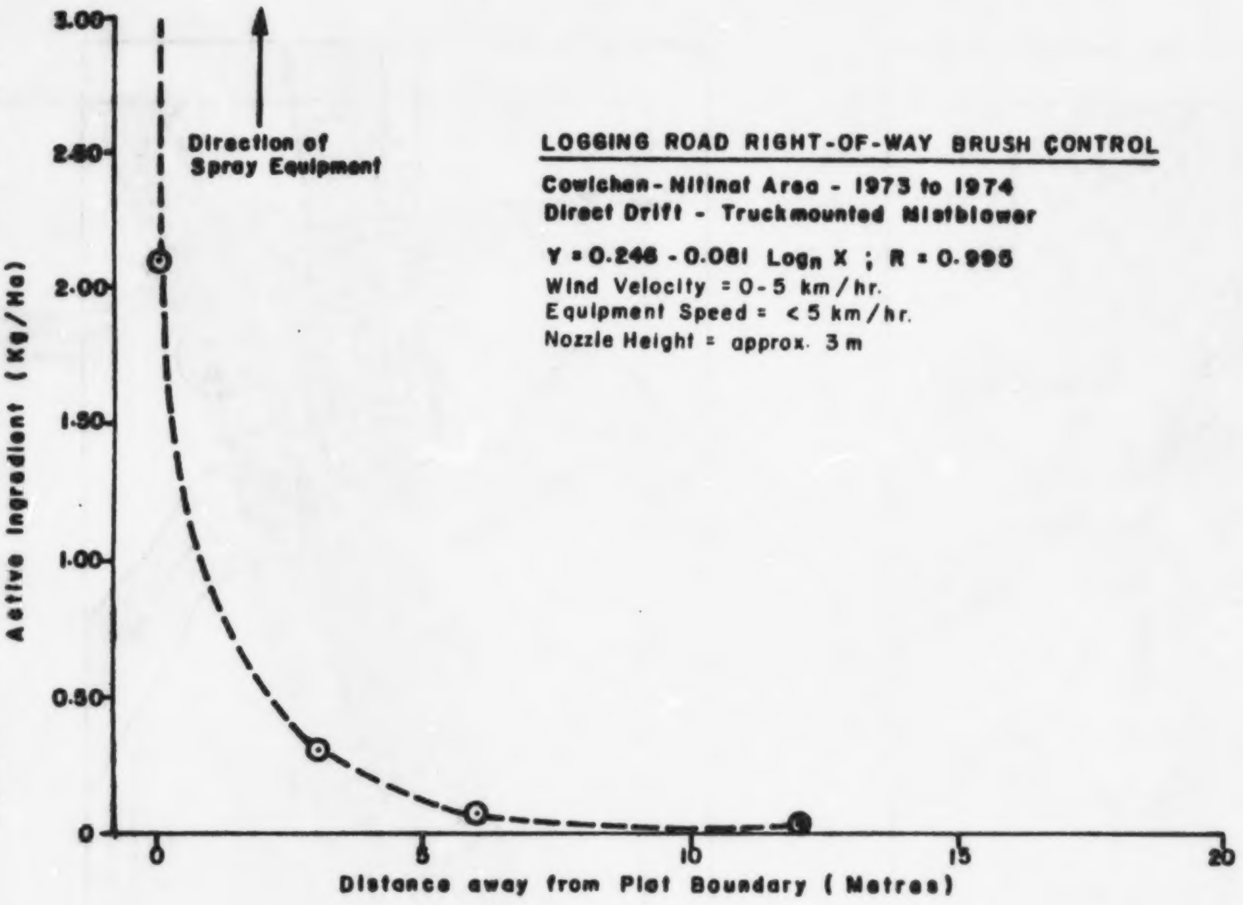


FIGURE 2-5 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No.	:	7
Monitoring Agency	:	Environmental Protection Service
Proponent of Project	:	Ministry of Highways

PROJECT DETAILS

Location	:	Selected sections of Highway No. 1, 3, 5.
Purpose	:	Soil sterilization of Highway shoulders
Target species	:	Canada Thistle, Knapweed
Treatment area	:	Spot treatment as required

PESTICIDE USE INFORMATION

Name of Pesticide	:	(1) Picloram, (2) Simazine
Active Ingredient	:	As above
Rate of Application	:	(1) 0.56 kg/ha, (2) 18 kg/ha
Carrier/diluent	:	Water
Drift Control Agent	:	NA
Application Method	:	Handgun/boom sprayers
Treatment Date	:	March - September as required on an annual basis

MONITORING OBJECTIVES

1. To determine herbicide concentrations in highway shoulders in central interior British Columbia

SUMMARY & CONCLUSIONS

Both picloram and simazine were applied on a selected spot treatment basis. Varying concentrations of these herbicides were found in the soil (depth 0-10 cm) throughout the highway shoulders of central interior British Columbia. Residues of picloram varied from 0.0025 to 0.54 ppm (averaging, 0.11 ppm), and of simazine, 0.04 to 0.20 ppm (averaging, 0.12 ppm).

REFERENCE

Wan, M.T. (1977) Environmental Protection Service Inspection Report Nos: 23, 25.

Monitoring Study No. : 8
Monitoring Agency : Environmental Protection Service
Proponent of Project : Canadian National Railway

PROJECT DETAILS
Location : Kamloops to Clearwater
Purpose : Soil sterilization of ballast
Target species : Horsetails, general weeds
Treatment area : Rail-line between Kamloops and Clearwater

PESTICIDE USE INFORMATION
Name of Pesticide : Atrazine
Active Ingredient : As above
Rate of Application : 18 kg/ha (i.e. 40 lbs/ac) formulated compound
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Rail mounted boom sprayer
Treatment Date : June/July (annually)

MONITORING OBJECTIVES

1. To evaluate the effectiveness of herbicidal soil sterilization of ballast, and
2. To determine the residue levels of atrazine in ballast, exchange clearings.

SUMMARY & CONCLUSIONS

Despite the annual herbicide application to the ballast, weed regeneration in many parts of the rail-line occurred soon after treatment. The residue levels varied considerably, (ie. 0.68 to 85.53 ppm), averaging 54.8 ppm. Such a variation in residue concentrations at different sections of the line appeared to indicate that the spray application was not conducted in a consistent manner. It appeared that part of the problem was related to the tight train schedules and spray contractors often had to meet the commitment of finishing a section of the line within a limited time frame. This probably resulted in the inconsistent coverage of some sections of the rail line.

REFERENCE

Wan, M.T. (1976) Environmental Protection Service Inspection Report File 4428-4-1 (1976).

Monitoring Study No. : 9
Monitoring Agency : Environmental Protection Service
Proponent of Project : Burlington Northern Rail

PROJECT DETAILS

Location : Vancouver to Blaine
Purpose : Soil sterilization of ballast
Target species : Horsetails, weeds
Treatment area : 40 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Elanco's Spike
Active Ingredient : Tebuthiuron
Rate of Application : 45 kg/ha (ie 4 lbs ai/ac)
Carrier/diluent : Water
Drift Control Agent : None
Application Method : Rail/truck mounted boom sprayer
Treatment Date : April 5 to April 16, 1976

MONITORING OBJECTIVES

1. To determine drift of a water/herbicide mixture when applied via a rail/truck mounted boom sprayer.
2. To determine the persistence of tebuthiuron in soil, air and water.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 2-6 and 2-7.

SUMMARY & CONCLUSIONS

Herbicide residues from a rail mounted boom sprayer were detected on drift plates placed at a perpendicular distance of up to 16 meters from the ballast. Although calm wind conditions prevailed at the time of the spray treatment, it was possible that the air turbulance caused by the movement of the rail mounted equipment was responsible for the herbicide drift.

No herbicide residues were detected in the water of ditches that were parallel to the rail track even though tebuthiuron residues were found in the air for up to 0.75 hours. However, it appeared conceivable that low levels of tebuthiuron may have occurred in the water, but remained undetected since the limit of detection of this herbicide at that time was 1.0 ppm.

Tebuthiuron persisted in the soil of the ballast for more than 16 days.

REFERENCES

Wan, M.T. (1978). Progress Report on Vegetation Control with Tebuthiuron - Burlington Northern Railway.

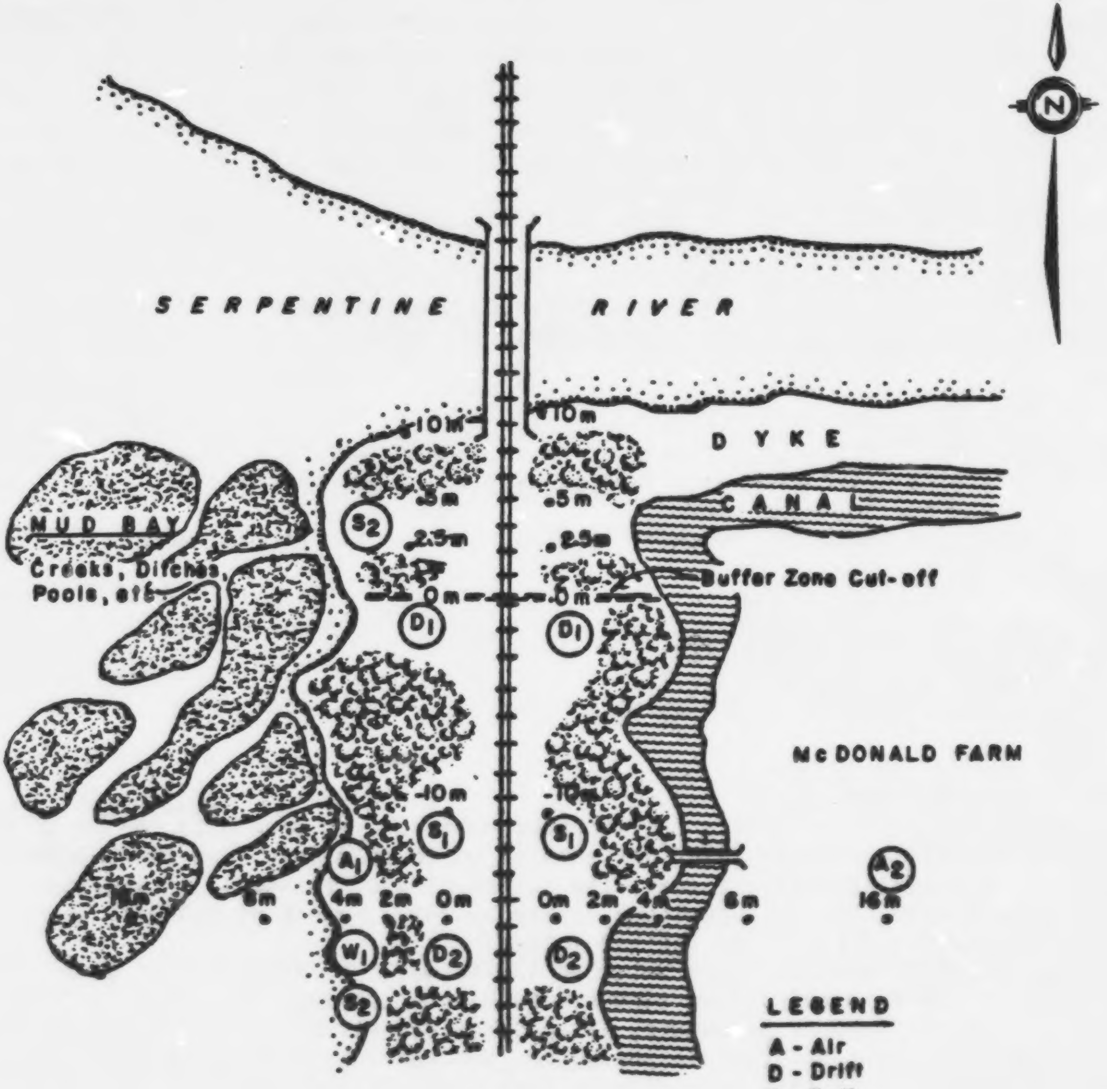

N
SERPENTINE RIVER
10m
10m
DYKE
CANAL
MUD BAY
Creeks, Ditches, Pools, etc
.5m
.5m
S2
2.5m
2.5m
Buffer Zone Cut-off
0m
0m
D1
D1
McDONALD FARM
-10m
-10m
S1
S1
A1
A2
16m
6m
4m
2m
0m
0m
2m
4m
6m
16m
W1
D2
D2
S2
LEGEND
A - Air
D - Drift
S - Soil
W - Water

FIGURE 2-6 DETAIL OF SPRAY AREA AND SAMPLE STATION LOCATIONS - SURREY, B.C.

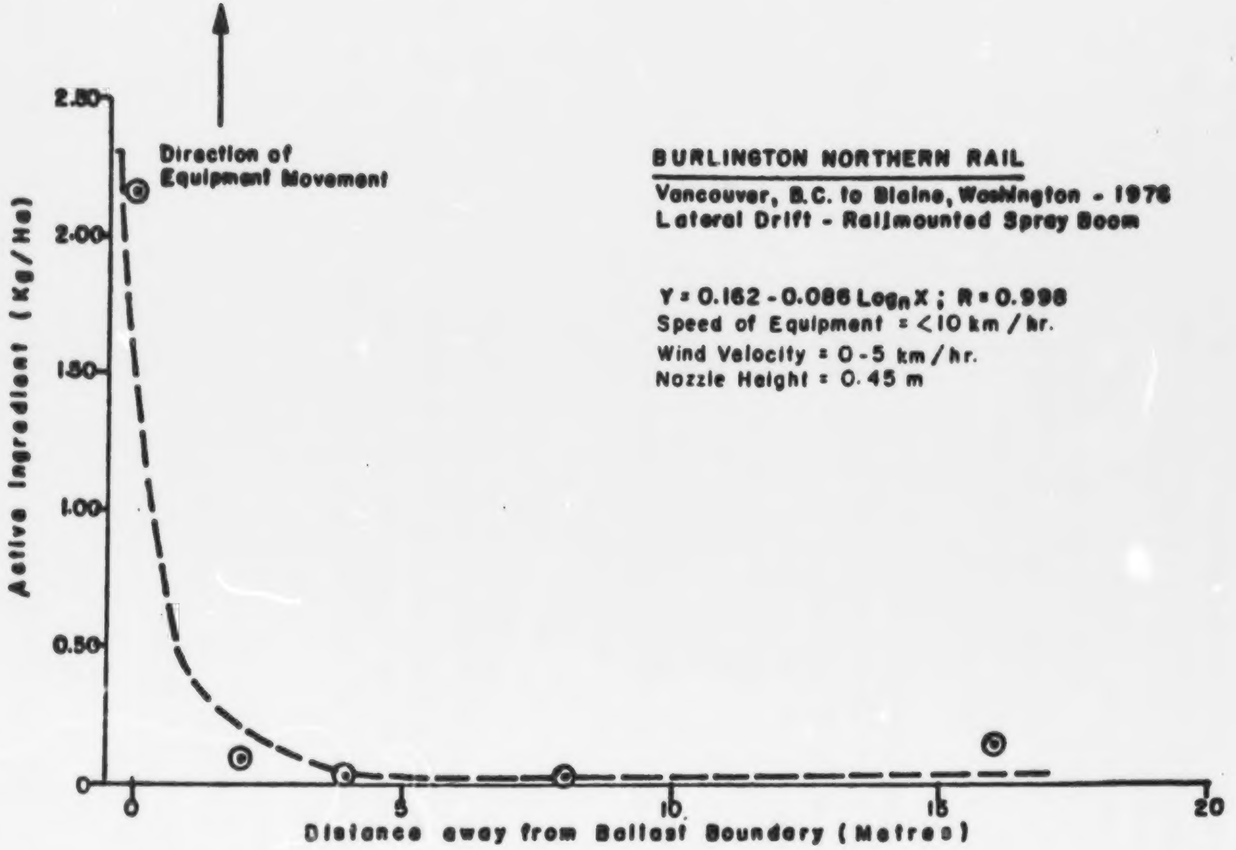


FIGURE 2-7 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No.	10
Monitoring Agency	Environmental Protection Service
Proponent of Project	British Columbia Hydro and Power Authority

PROJECT DETAILS

Location	Sechelt Peninsula
Purpose	Powerline right-of-way brush control
Target species	Alder, salmonberry
Treatment area	18 ha

PESTICIDE USE INFORMATION

Name of Pesticide	2,4-D/2,4,5-T (Iso-octylester formulation)
Active Ingredient	As above
Rate of Application	4.5 kg/ha
Carrier/diluent	Water
Drift Control Agent	None
Application Method	Aerial dormant spray (fixed wing aircraft)
Treatment Date	April 4, 1975 (0700 hours)

MONITORING OBJECTIVES

1. To determine drift of liquid herbicide application from a fixed wing aircraft along powerline right-of-way;
2. To evaluate the minimum buffer zone required for the protection of streambank vegetation and water from herbicide contamination;
3. To monitor the persistence of 2,4-D/2,4,5-T residues in contaminated streams.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 2-8 and 2-9.

SUMMARY OF RESULTS

Herbicide residues were detected on drift plates placed at a distance of up to 45 meters away from the border of the treatment area along the flight path the of the aircraft. Regression data on drift concentrations versus distances away from the spray area indicated that herbicide residues could potentially drift for more than 150 meters under the prevailing wind condition of this spray treatment (ie, less than 5 km/h).

This fixed wing application contaminated streams that flowed through the treatment area even though a 45 meter buffer zone was observed on both sides of the water courses (see Figure 2-8). High concentrations of herbicide (up to 5.76 ppm 2,4-D, 6.05 ppm 2,4,5-T) were found in the stream water soon after the aerial treatment. Although the concentration of herbicides decreased substantially (i.e., to 0.06 ppm 2,4-D, 0.09 ppm 2,4,5-T) 2 hours following the spray application, residues were detected in the stream water for up to 5 hours after treatment.

CONCLUSIONS

1. Fixed wing application of liquid herbicide along the powerline right-of-way not only produced extensive drift but also had a potential for contaminating areas up to a distance of more than 150 meters away from the spray boundary.
2. The minimum buffer zone required for the protection of streambank vegetation and water from herbicide contamination should not be less than 150 meters from the treatment boundary.
3. Fixed wing aerial application has the potential to contaminate water courses for a long period of time

REFERENCE

Wilson, D.M. and Wan, M.T.K. (1975). Effectiveness of Stream Buffer Zones during Aerial Applications of Chlorophenoxy and Picloram Herbicides. Report Number E.P.S. 5-PR-75-3.

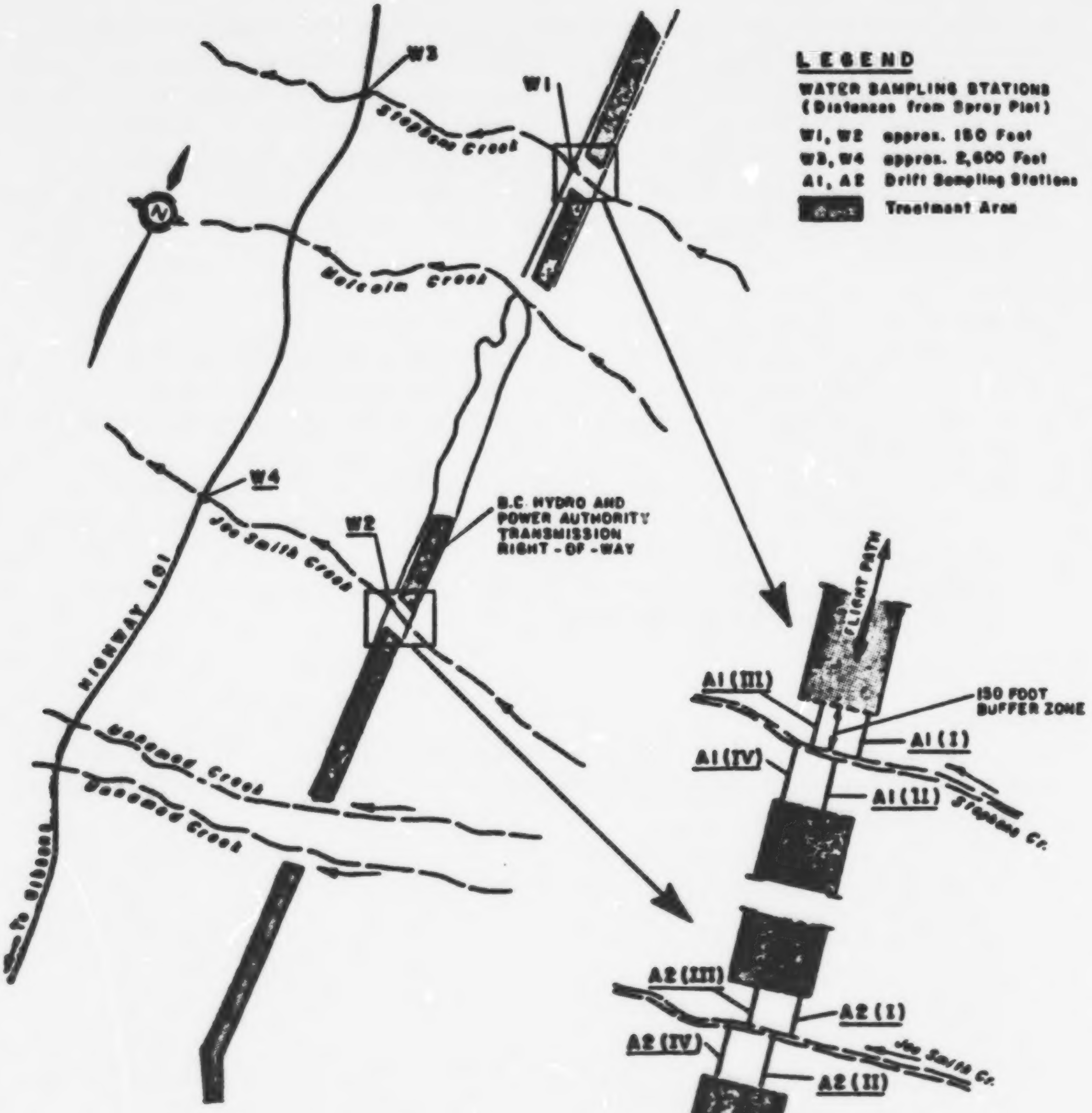

LEGEND
WATER SAMPLING STATIONS
(Distances from Spray Plot)
W1, W2 approx. 150 Feet
W3, W4 approx. 2,600 Feet
A1, A2 Drift Sampling Stations
Treatment Area
N
W3
W1
Stephens Creek
Malcolm Creek
W4
W2
Joe Smith Creek
B.C. HYDRO AND POWER AUTHORITY TRANSMISSION RIGHT - OF - WAY
HIGHWAY 101
Unnamed Creek
Unnamed Creek
To Gibsons
FLIGHT PATH
A1 (III)
150 FOOT BUFFER ZONE
A1 (I)
A1 (IV)
A1 (II)
Stephens Cr.
A2 (III)
A2 (I)
A2 (IV)
A2 (II)
Joe Smith Cr.

FIGURE 2-8 DIAGRAM OF SPRAY PLOT - SECHELT, B. C.

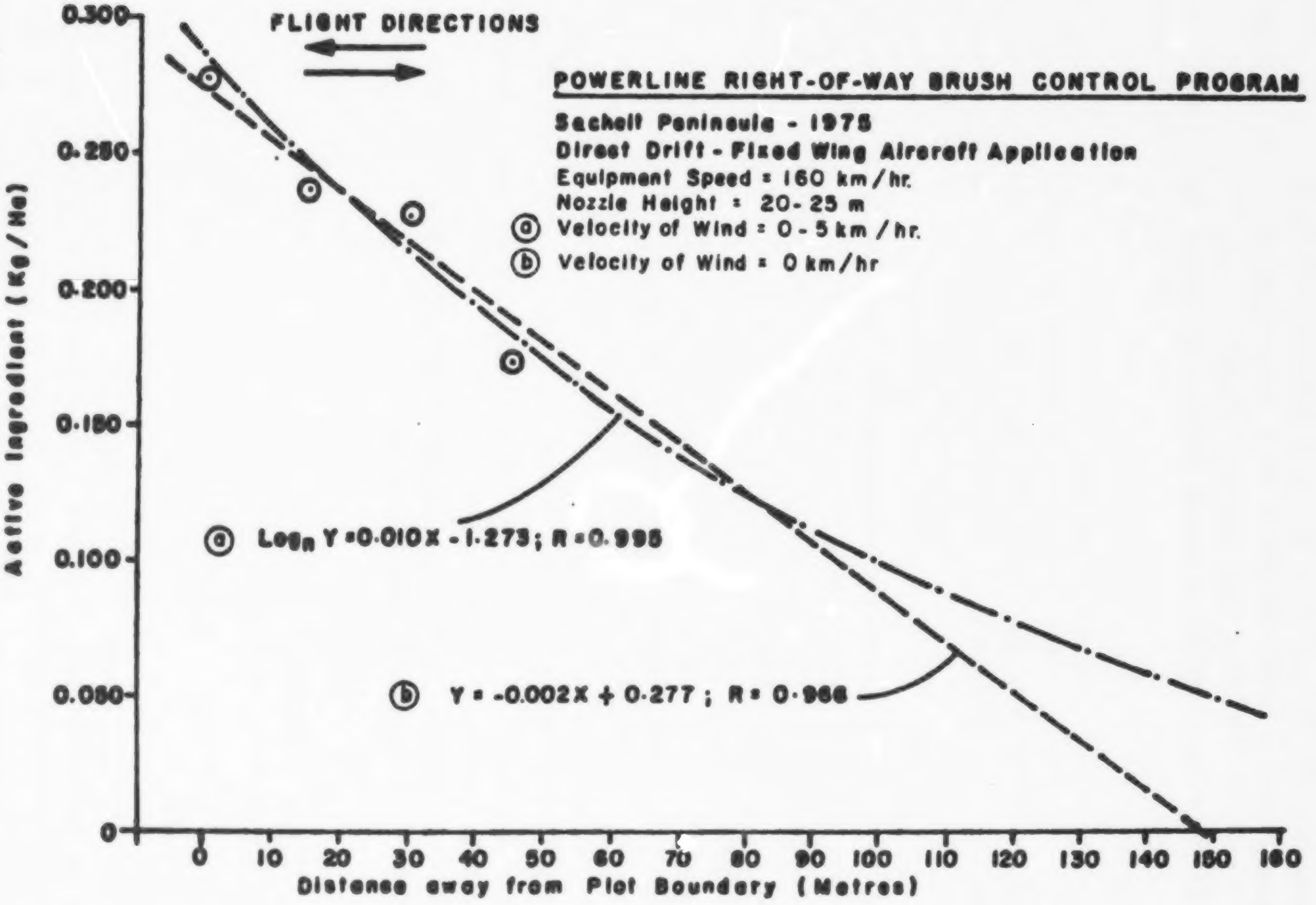


FIGURE 2-9 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No.	:	11
Monitoring Agency	:	Environmental Protection Service/British Columbia Fish and Wildlife Branch
Proponent of Project	:	British Columbia Hydro and Power Authority

PROJECT DETAILS

Location	:	McLeese Lake area
Purpose	:	Powerline right-of-way brush control
Target species	:	Alder, Pine, Poplar, Birch
Treatment area	:	92 ha

PESTICIDE USE INFORMATION

Name of Pesticide	:	Tordon 10K pellets
Active Ingredient	:	Picloram
Rate of Application	:	67.5 kg/ha
Carrier/diluent	:	None
Drift Control Agent	:	None
Application Method	:	Aerial dormant spray (fixed wing aircraft)
Treatment Date	:	May 1, 1976 (0530 - 1130 hours)

MONITORING OBJECTIVES

1. To determine the drift of a herbicide pellet application from a fixed wing aircraft along a powerline right-of-way;
2. To evaluate the minimum buffer zone required for the protection of wetland areas from herbicide contamination;

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 2-10, 2-11, and 2-12.

SUMMARY OF RESULTS

Picloram pellets were found on drift panels and plates placed at a distance of up to 20 meters away from the boundary of the treatment area (see Figure 2-11, 2-12). Regression data on the number of pellets collected per panel/plate versus distances away from the spray area indicated that herbicide pellets have the potential to drift to a distance of more than 25 meters under variable prevailing wind conditions of 3-24 kmph. Although the drift problem of fixed wing application of herbicide pellets was not as extensive as the liquid form, there was a need to observe an appropriate additional buffer for the protection of streambank vegetation and water because picloram is highly mobile in soil. Picloram was detected at 0.20 ppm in the water of a pond that was located approximately 30 meters away from the boundary of treatment area.

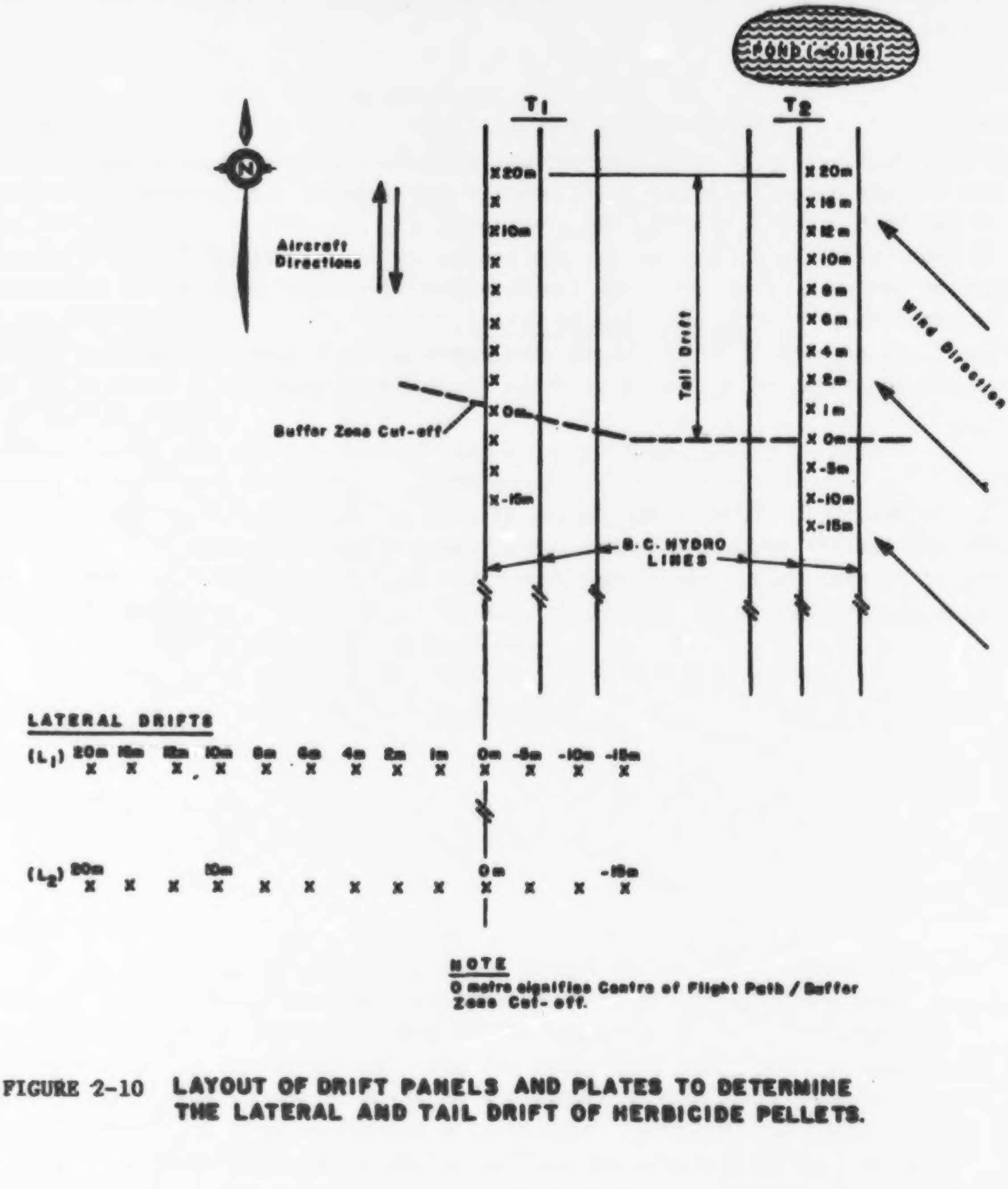
Accordingly, an additional 25 to 75 meters should have been added to the 25 meter buffer zone, depending on the material used and the topography of the treatment area.

CONCLUSIONS

1. Fixed wing application of herbicide pellets along a powerline right-of-way did not produce extensive spray drift despite the variable wind velocity conditions that prevailed during the treatment.
2. The minimum buffer zone required for the protection of streambank vegetation and water from herbicide contamination for aerial pellet application should not be less than 50 meters.
3. To reduce the problem of drift, fixed wing application of herbicide pellets should not be conducted at a wind velocity greater than 5 kmph.

REFERENCE

Reid, D.S. and Wan, M.T. (1976). Monitoring of a fixed wing aerial broadcast of picloram pellets for British Columbia Hydro Transmission right-of-way maintenance at McLeese Lake. Joint memo report E.P.S./Fish and Wildlife.


POND (~0.1ha)
N
Aircraft Directions
T1
T2
X 20m
X
X 10m
X
X
X
X
X
X 0m
X
X
X -10m
X 20m
X 16m
X 12m
X 10m
X 8m
X 6m
X 4m
X 2m
X 1m
X 0m
X -5m
X -10m
X -15m
Tail Drift
Wind Direction
Buffer Zone Cut-off
B.C. HYDRO LINES
LATERAL DRIFTS
(L1) 20m 16m 12m 10m 8m 6m 4m 2m 1m 0m -5m -10m -15m
(L2) 20m 10m 0m -15m

NOTE
0 metre signifies Centre of Flight Path / Buffer Zone Cut-off.

FIGURE 2-10 LAYOUT OF DRIFT PANELS AND PLATES TO DETERMINE THE LATERAL AND TAIL DRIFT OF HERBICIDE PELLETS.

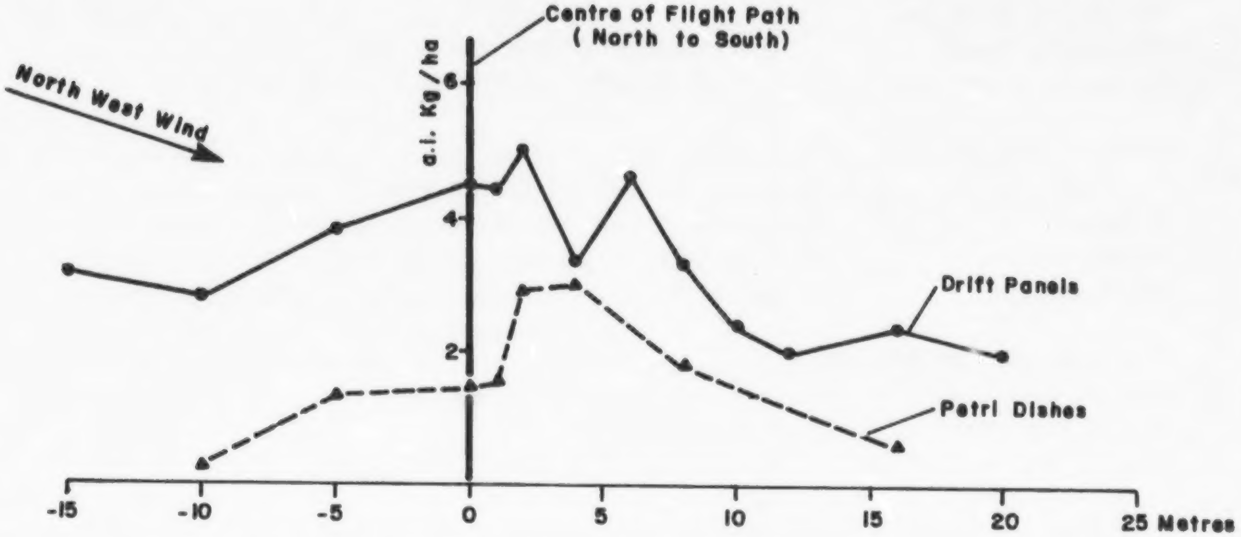


FIGURE 2-11 LATERAL DRIFT OF PICLORAM PELLETS FROM A FIXED WING AIRCRAFT

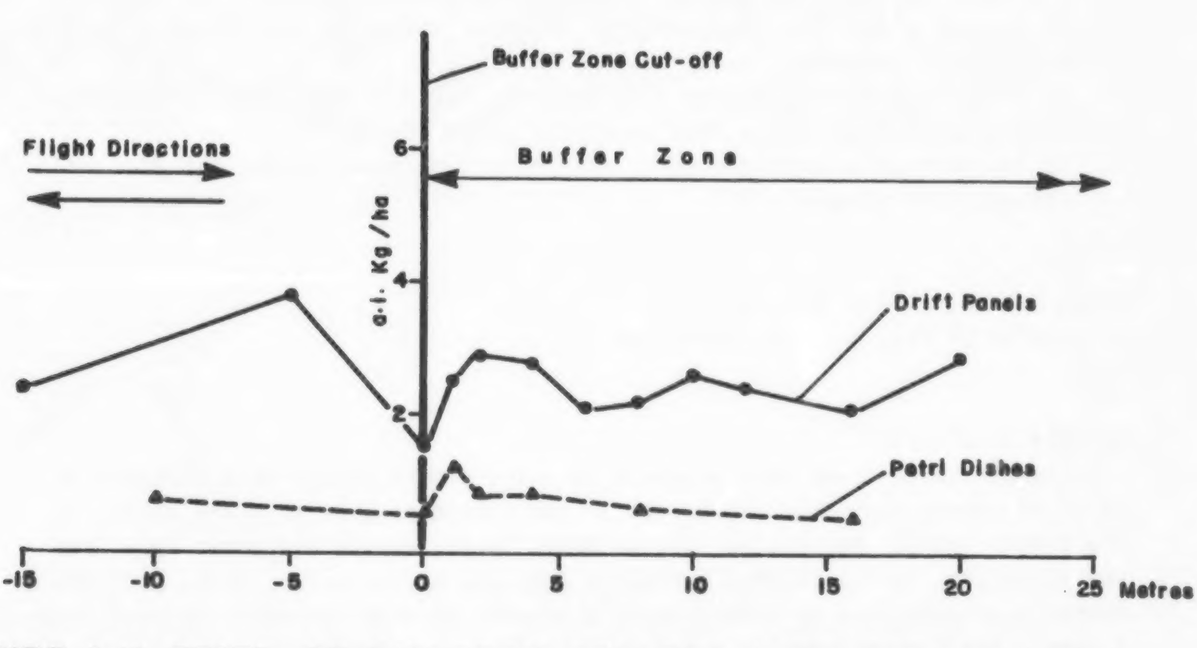


FIGURE 2-12 DRIFT OF PICLORAM PELLETS INTO BUFFER ZONE AREA FROM A FIXED WING AIRCRAFT

Monitoring Study No. : 12
Monitoring Agency : Environmental Protection Service
Proponent of Project : British Columbia Hydro and Power Authority

PROJECT DETAILS
Location : Pemberton - Mount Currie area
Purpose : Powerline right-of-way brush control
Target species : Alder, Poplar, Birch
Treatment area : 110.4 ha

PESTICIDE USE INFORMATION
Name of Pesticide : Picloram/2,4-D amine mixture
Active Ingredient : As above
Rate of Application : 10.5 kg/ha (Picloram: 2,4-D = 1:4)
Carrier/diluent : Water
Drift Control Agent : Norbak
Application Method : Aerial foliar application (Helicopter)
Treatment Date : July 25, 1975 (0730 hours)

MONITORING OBJECTIVES

1. To determine the drift pattern of liquid herbicide application from a helicopter along the flight path or at right angles to the flight path in a powerline right-of-way brush control program;
2. To assess the minimum buffer zone required for the protection of streambank vegetation and wet areas from herbicide contamination;
3. To monitor the persistence of 2,4-D/picloram residues in the air and contaminated streams.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 2-13, 2-14, and 2-15.

SUMMARY OF RESULTS

Herbicide residues were detected on drift plates placed at a distance of up to 45 meters away from the border of the treatment area at right angles to the flight paths. Regression data on drift levels versus distances away from the spray plot indicated that herbicide droplets have a potential to drift to a distance of more than 80 meters under a prevailing wind condition of less than 5 kmph. Small quantities of 2,4-D and picloram were detected in a stream 0-2 hours following the spray application (i.e., totalling 0.50 ppm). This decreased to 0.023 ppm, 2-4 hours later because of the high rate of stream discharge (i.e., 10 cfs). Picloram/2,4-D residues persisted in the air for up to four hours after the beginning of the spray.

CONCLUSIONS

1. Helicopter application of liquid herbicide mixture during a right-of-way brush control program has a high potential of contaminating wetland areas up to a distance of more than 80 meters away from the spray boundary.
2. The minimum buffer zone required for the protection of streambank vegetation and water from herbicide contamination should not be less than 100 meters from the treatment boundary.
3. Pesticide residues did not persist in the creek because of the high stream discharge rate (i.e., 10 cfs).

REFERENCE

Wilson, D.M. & M.T. Wan (1975). Effectiveness of Stream Buffer Zones during Aerial Applications of Chlorophenoxy and Picloram Herbicides. Environmental Protection Service. E.P.S. 5-PR-75-3.

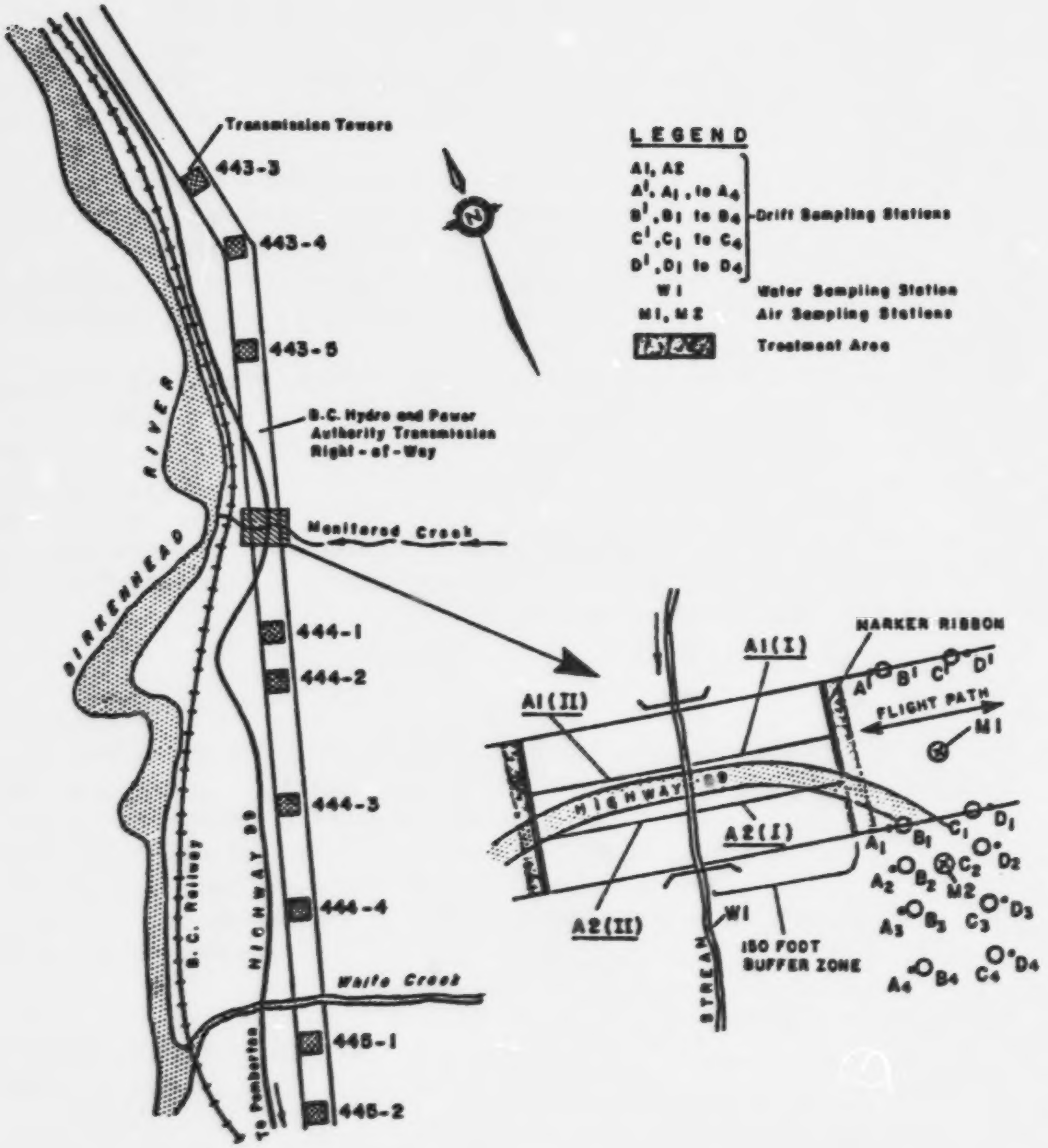

Transmission Towers
443-3
443-4
443-5
444-1
444-2
444-3
444-4
445-1
445-2
N
LEGEND
A1, A2
A', A1, to A4
B', B1 to B4
C', C1 to C4
D', D1 to D4
Drift Sampling Stations
W1 Water Sampling Station
M1, M2 Air Sampling Stations
Treatment Area
B.C. Hydro and Power Authority Transmission Right-of-Way
BIRKENHEAD RIVER
Monitored Creek
B.C. Railway
HIGHWAY 99
Wolfe Creek
To Pemberton
MARKER RIBBON
A1(I)
A1(II)
A2(I)
A2(II)
FLIGHT PATH
HIGHWAY 99
STREAM
W1
150 FOOT BUFFER ZONE
A' B' C' D'
M1
A1 B1 C1 D1
A2 B2 C2 D2
M2
A3 B3 C3 D3
A4 B4 C4 D4

FIGURE 2-13 **DIAGRAM OF SPRAY PLOT - PEMBERTON, MOUNT CURRIE, B.C.**

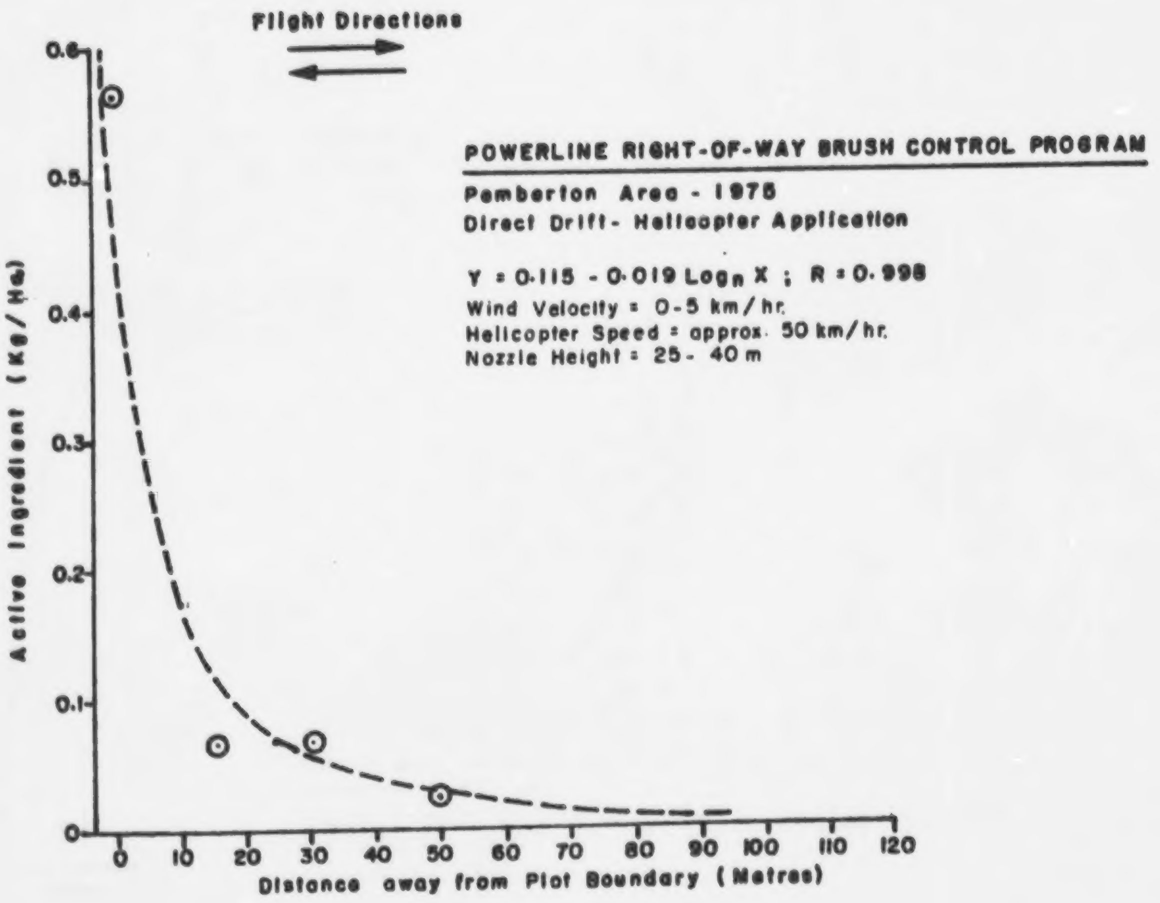


FIGURE 2-14 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

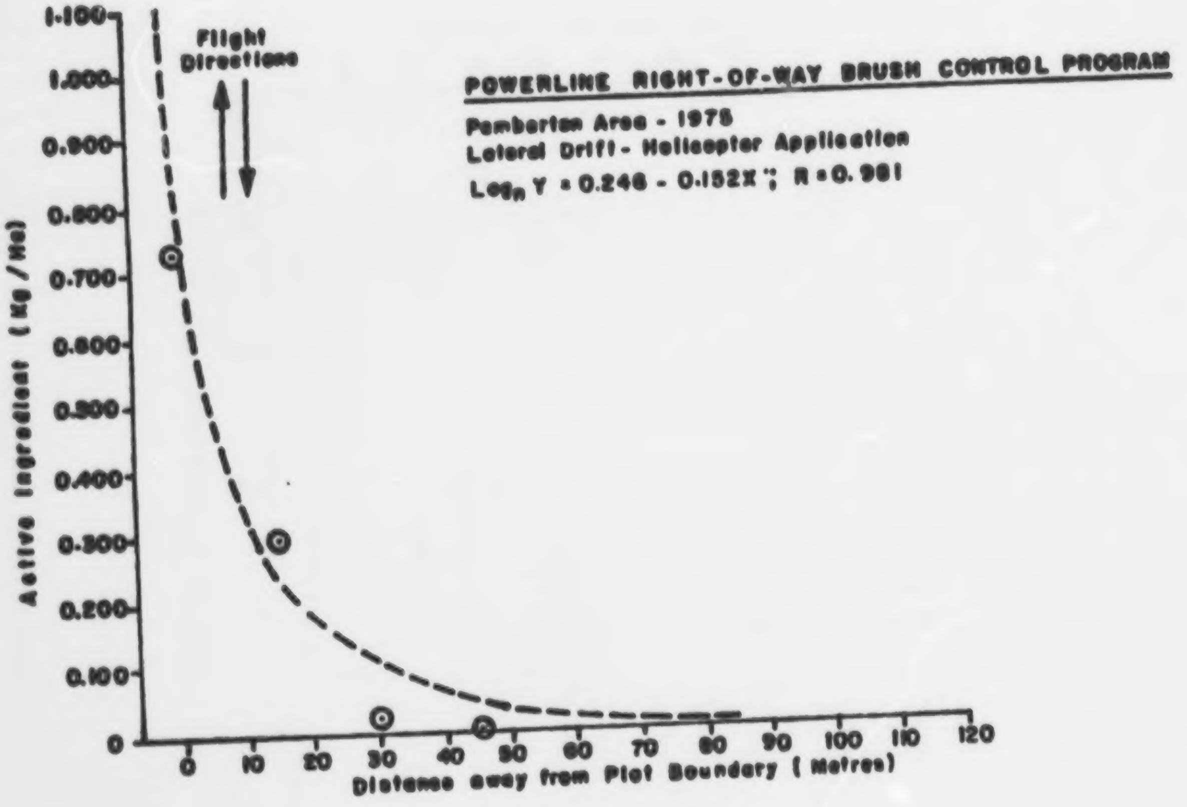


FIGURE 2-15 RELATIONSHIP BETWEEN DRIFT DEPOSITION AND DISTANCE

Monitoring Study No. : 13
Monitoring Agency : Environmental Protection Service
Proponent of Project : Transport Canada

PROJECT DETAILS

Location : Boundary Bay Airport, Delta
Purpose : Weed Control
Target species : Canada and Bull Thistle
Treatment area : 38 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Dicamba
Active Ingredient : As above
Rate of Application : 1.26 kg ai/ha
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Tractor Mounted boom sprayer
Treatment Date : June 6, 1981

MONITORING OBJECTIVE

1. To monitor the residue and movement of dicamba following one application of this herbicide to control thistles along the runway of Boundary Bay Airport.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figure 2-16.

SUMMARY OF RESULTS

Minute concentrations of dicamba (ie., 2.2 ppb) were recovered from the ditch water along the runway three days following herbicide treatment. No residues, however, were found in water leading to the dyke canal.

REFERENCE

Wan, M.T. (1981). Dicamba Residues in Runoff Water at Boundary Bay Airport, Delta, B.C. Environmental Protection Service Memo Report, July 13, 1981.

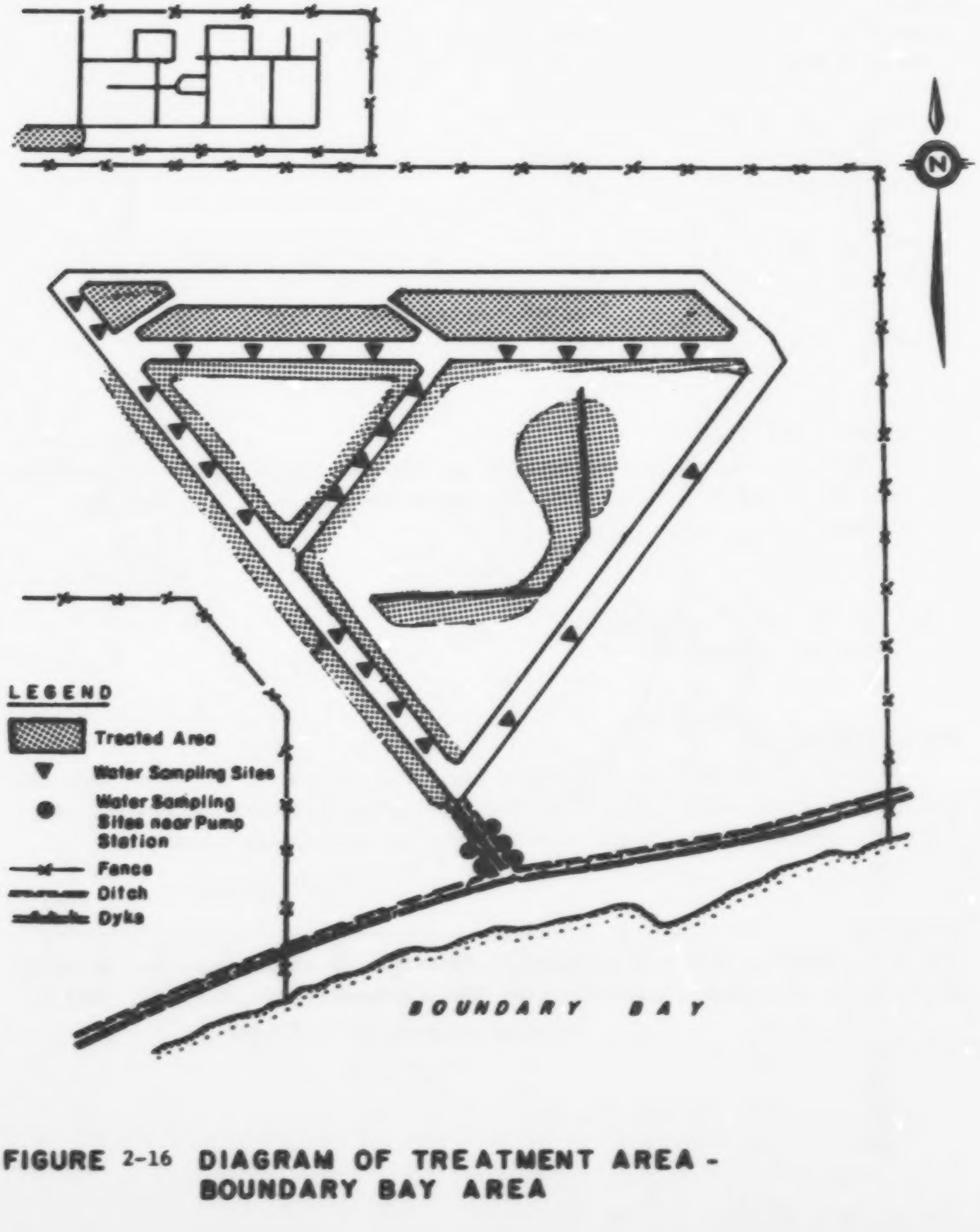

N
LEGEND
Treated Area
Water Sampling Sites
Water Sampling Sites near Pump Station
Fence
Ditch
Dyke
BOUNDARY BAY

FIGURE 2-16 DIAGRAM OF TREATMENT AREA - BOUNDARY BAY AREA

APPENDIX III

FORESTRY INSECT PEST CONTROL PROGRAMMES

Monitoring Study No. : 14
Monitoring Agency : Environmental Protection Service
Proponent of Project : MacMillan Bloedel/Rayonier Canada

PROJECT DETAILS

Location : North of Vancouver Island, Neroutsos Inlet area
Purpose : Control of insect pests
Target species : Black headed budworm
Treatment area : 29,000 acres

PESTICIDE USE INFORMATION

Name of Pesticide : Sumithion
Active Ingredient : Fenitrothion
Rate of Application : 0.14 kg ai/ha x2
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Fixed wing aircraft (Cessna Skymaster)
Treatment Date : June 22, 1973/June 26, 1973

MONITORING OBJECTIVE

1. To determine the impact of fenitrothion on non-target Arthropods.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figure 3-1 and Table 3-1.

SUMMARY OF RESULTS

There was a significant reduction in the numbers of some orders of non-target arthropoda, particularly the arachnida and diptera, in the treated plots after insecticide application.

CONCLUSION

There was considerable mortality of several families of terrestrial insects following the insecticide treatment.

REFERENCE

1. Aerial Spraying Operations Against Blackheaded Budworm on Vancouver Island - 1973. Edited by J.R. Carrow Pacific Forest Research Centre, 506 West Burnside Road, Victoria, B.C.

2. Wan, M.T. (1974). The Effects of Fenitrothion on non-target Arthropods. E.P.S. Manuscript Report 74-3, Pacific Region.

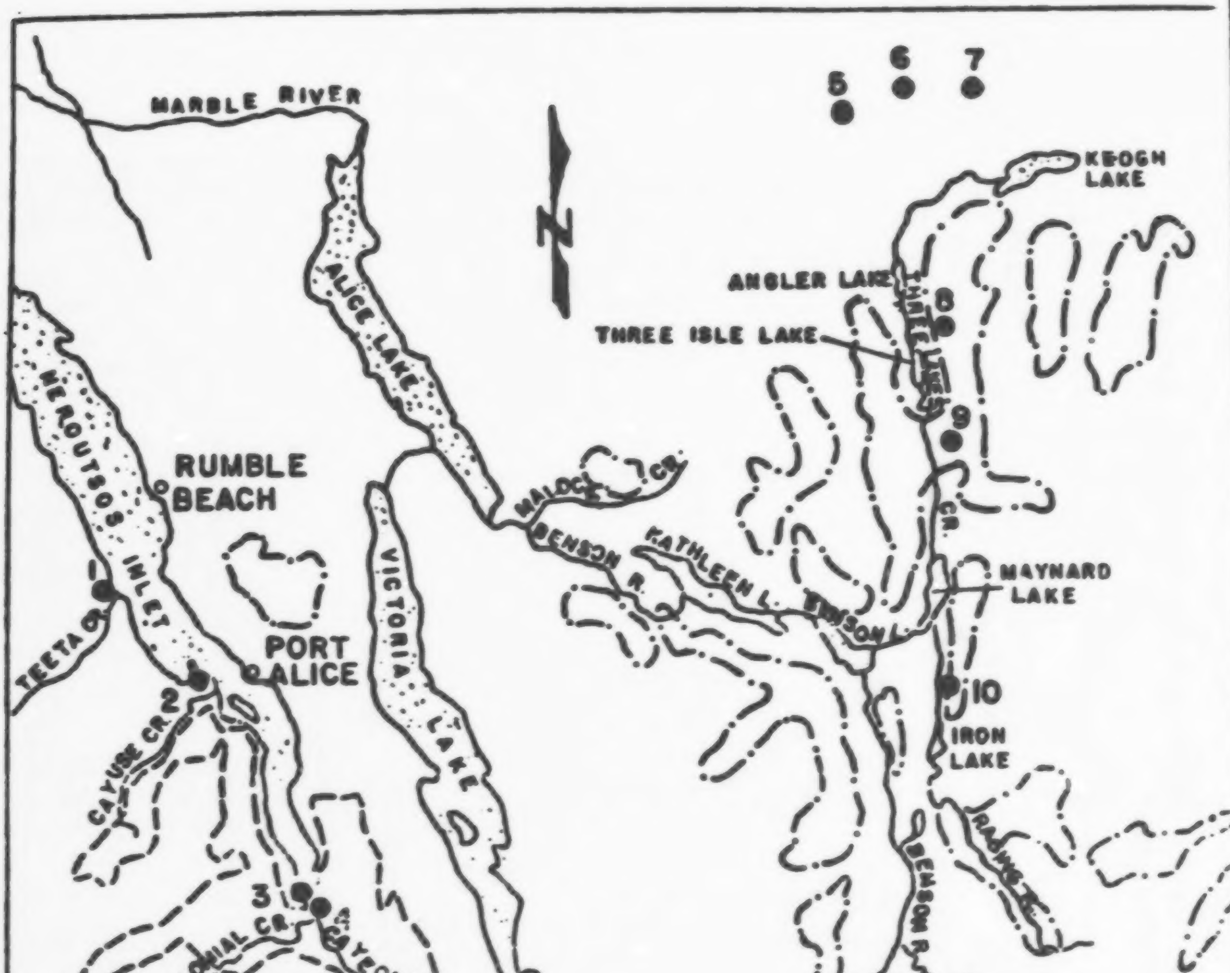

MARBLE RIVER
N
5
6
7
KEOGH LAKE
ANGLER LAKE
8
THREE ISLE LAKE
9
CR.
ALICE LAKE
NEROUTSOS INLET
RUMBLE BEACH
MALDOE CR.
BENSON R.
KATHLEEN L.
BENSON L.
MAYNARD LAKE
1
TEETA CR.
PORT ALICE
2
CAYUSE CR.
VICTORIA LAKE
10
IRON LAKE
BENSON R.
3
COLONIAL CR.
CAYECHLE CR.
UTLUH CR.
MARBLE RIVER
LEGEND
SPRAY AREAS ON RAYONIER HOLDINGS
SPRAY AREAS ON McMILLAN BLOEDEL HOLDINGS.
SAMPLING SITE
0 1/2 1 2 3
SCALE IN MILES

FIGURE 3-1
LOCATIONS OF POPULATION SAMPLING OF NON-TARGET ARTHROPODS

TABLE 3-1: CHANGES IN NET-SWEEP ARTHROPOD POPULATIONS IN UNSPRAYED PLOTS AND IN PLOTS SPRAYED WITH FENITROTHION

ARTHROPODS[a]	Number Collected		Change[b]	Number Collected		Change[b]
	Pre-spray (June 19)	Post-spray (June 26)		Pre-spray (June 20)	Post-spray (June 26)	
Arachnida	19	329	17.32	85	216	2.54
Coleoptera	41	46	1.12	23	27	1.17
Diplopoda	4	1	--	1	0	--
Diptera	145	453	3.12	701	221	0.31
Ephemeroptera	3	1	--	2	1	--
Hemiptera	140	63	0.45	7975	2413	0.30
Hymenoptera	95	59	0.63	43	33	0.76
Lepidoptera	13	3	0.23	79	21	0.26
Neuroptera	1	0	--	1	1	--
Mollusca	3	2	--	1	2	--
Plecoptera	0	1	--	1	0	--
Thysanoptera	4	7	1.75	2	5	2.50
Trichoptera	5	2	0.40	3	1	--
Total Numbers[c]	473	967	2.04	8917	2941	0.33

[a] Immature and Adult stages.

[b] Change = $\frac{\text{post-spray number}}{\text{pre-spray number}}$; >1 = increase, <1 = decrease; change involving populations <5 considered insignificant.

[c] Ten plots per sampling date.

Monitoring Study No. : 15
Monitoring Agency : Environmental Protection Service
Proponent of Project : Canadian Forestry Service

PROJECT DETAILS
Location : Revelstoke area
Purpose : Forestry Insect pests control
Target species : Western Hemlock Looper
Treatment area : 28 ha

PESTICIDE USE INFORMATION
Name of Pesticide : Altosid insect juvenile hormone
Active Ingredient : Methoprene
Rate of Application : 0.145 l ai/ha
Carrier/diluent : Water/Rhodomine dye
Drift Control Agent : NA
Application Method : Fixed wing aircraft
Treatment Date : July 30, 1974

MONITORING OBJECTIVE

1. To monitor the effects of this juvenile hormone on aquatic and terrestrial invertebrates.

STUDY DESIGN, LAYOUT, AND RESULTS

Refer to Figures 3-2, 3-3, and 3-4.

SUMMARY OF RESULTS

Significantly lower rates of insect emergence from aquatic insect cages were recorded on the 6th and 31st day following the hormone application in the altosid treated ponds but not the treated creek.

Some reduction in emergence and moulting of organisms after hormone treatment was observed although there was no evidence of harmful effects of Altosid.

CONCLUSION

Altosid juvenile hormone appears to have minimal short term impact on non-target aquatic and terrestrial invertebrates.

REFERENCE

Wan, M.T.K. and D.M. Wilson (1975). Impacts of Altosid Juvenile Hormone on Non-target Organisms in an Aquatic Environment of British Columbia. Surveillance Report. E.P.S. 5-PR-75-9, Pacific Region.

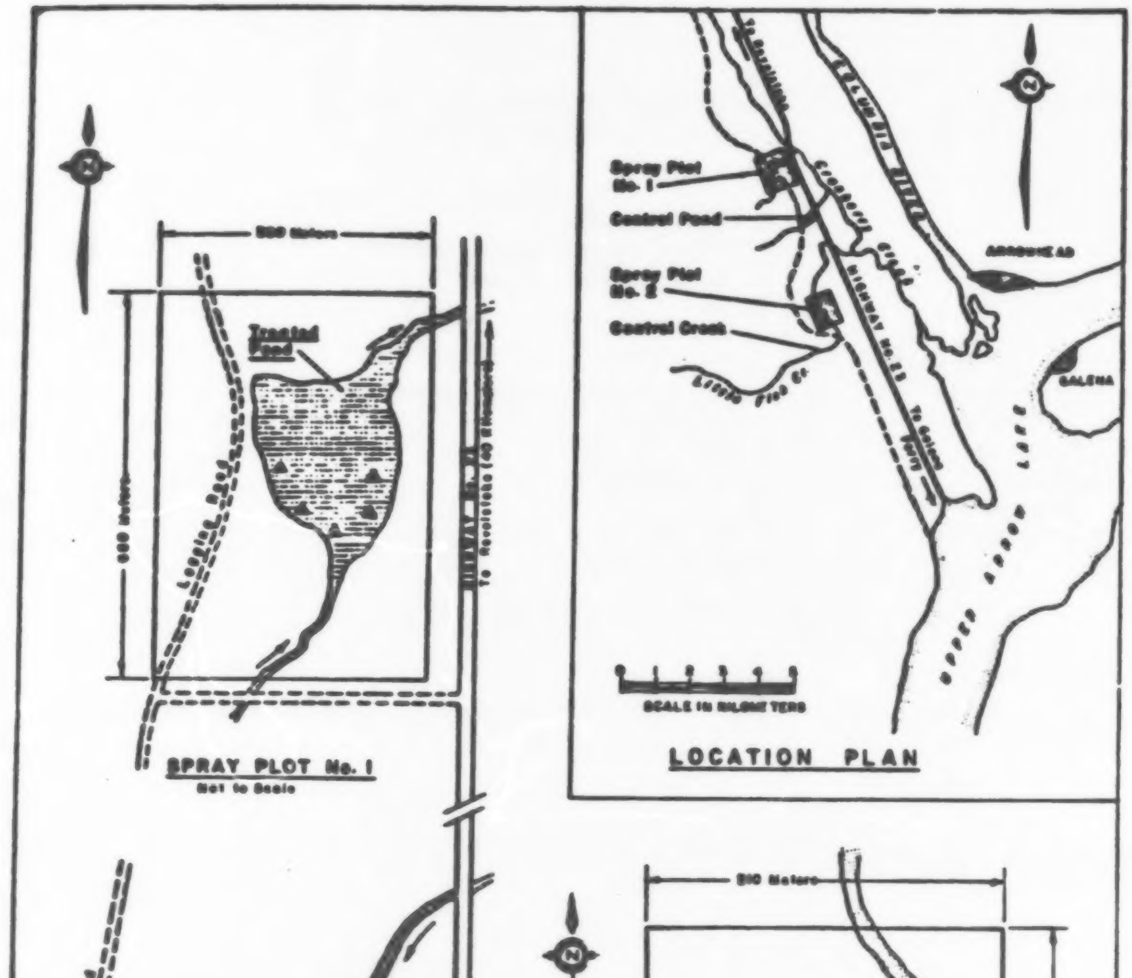

Treated Pond
Logging Road
SPRAY PLOT No. 1
Not to Scale
Spray Plot No. 1
Control Pond
Spray Plot No. 2
Control Creek
Little Fish Cr.
HIGHWAY No. 23
To Galena Ferry
ARROWHEAD
GALENA
UPPER ARROW LAKE
SCALE IN KILOMETERS
LOCATION PLAN
Logging Road
Control Pond
To Galena Ferry
Treated Creek
SPRAY PLOT No. 2
Not to Scale
Control Creek
LEGEND
▲ Insect Emergence Cages

FIGURE 3-2 LOCATION OF SPRAY PLOTS

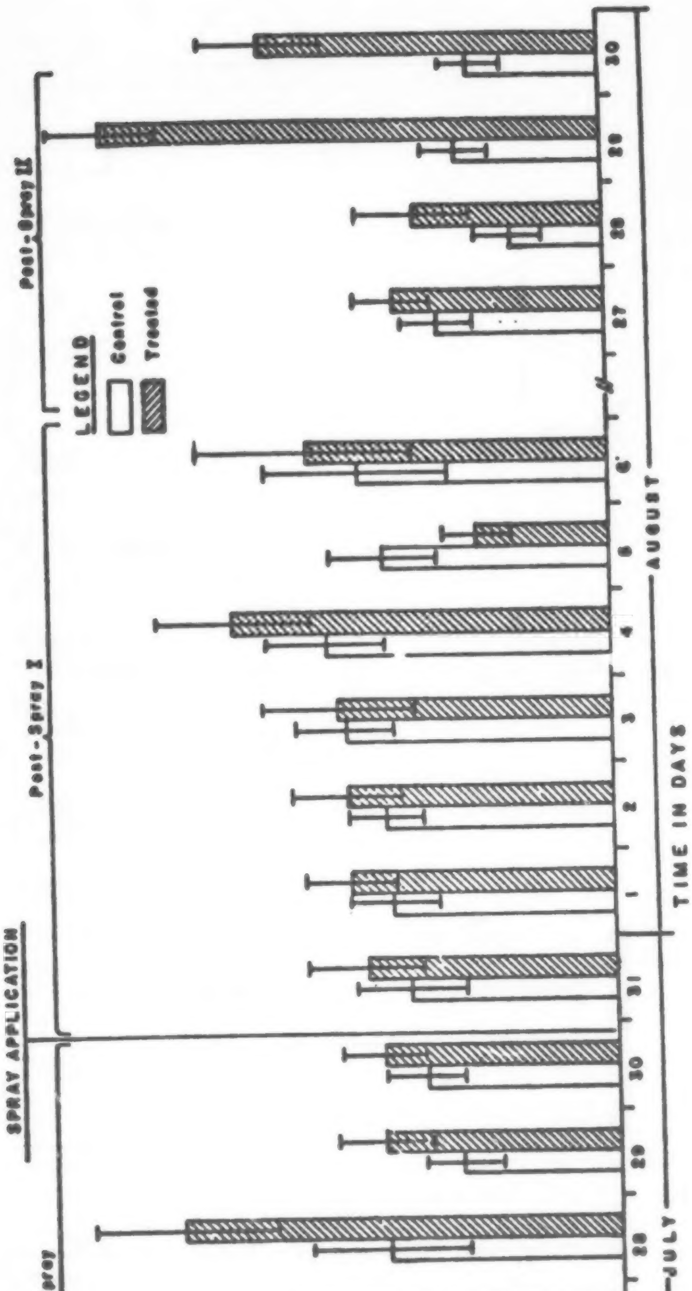


FIGURE 3-3 RATE OF EMERGENCE OF ARTHROPODS IN CONTROL AND ALTOSID-TREATED PONDS

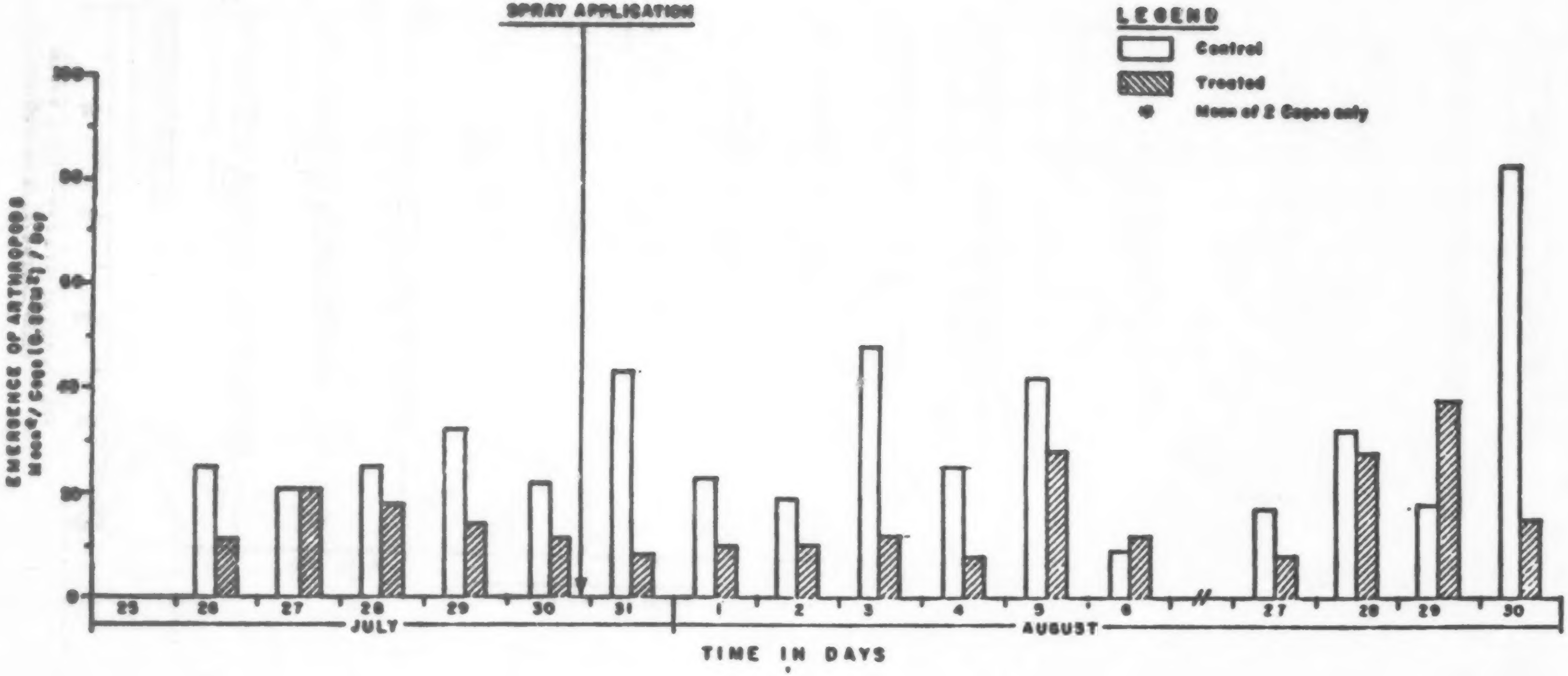


FIGURE 3-4 RATE OF EMERGENCE OF ARTHROPODS IN CONTROL AND ALTOSID-TREATED CREEK STATIONS

Monitoring Study No. : 16
Monitoring Agency : Environmental Protection Service
Proponent of Project : Canadian Forestry Service/British Columbia/United States Departments of Agriculture

PROJECT DETAILS

Location : Kamloops area
Purpose : Control of forest insect pest
Target species : Douglas-fir tussock moth
Treatment area : 12,140 ha

PESTICIDE USE INFORMATION

Name of Pesticide : (i) Orthene, (ii) Dimilin
Active Ingredient : As above
Rate of Application : (i) 1.12 kg ai/ha (ii) 0.14 kg ai/ha
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Fixed wing aircraft (Cessna)
Treatment Date : June, 1975

MONITORING OBJECTIVE

1. To monitor the impacts of orthene and dimilin on non-target arthropods in a Douglas-fir forest environment

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 3-5 and 3-6.

SUMMARY OF RESULTS

Operational aerial application of orthene and dimilin reduced the population of arboreal, grass-dwelling, soil-dwelling, and flying insects for varying periods of time following insecticide treatment.

CONCLUSIONS

Aerial application of orthene and dimilin was injurous to a number of non-target arthropod groups in the forest ecosystem. Orthene had an adulticidal effect on insects, while dimilin inhibited the emergence of adult insects. The effect of orthene was short-lived but Dimilin appeared to sustain its effect on adult emergence during the period of investigation. Residues of Orthene and its principal metabolite, monitor, contaminated the forest floor for more than one week.

REFERENCE

1. Canadian Forestry Service (1980). Operational Field Trials Against the Douglas-fir Tussock Moth with Chemical and Biological Insecticides. Pacific Forest Research Centre, Victoria. Report BC-X-201.
2. Wilson, D.M. and M.T.K. Wan (1977). Effects of Orthene and Dimilin Insecticides on selected non-target Arthropods in a Douglas-fir Forest Environment. Surveillance Report, E.P.S.-5-PR-76-4, (Final draft).

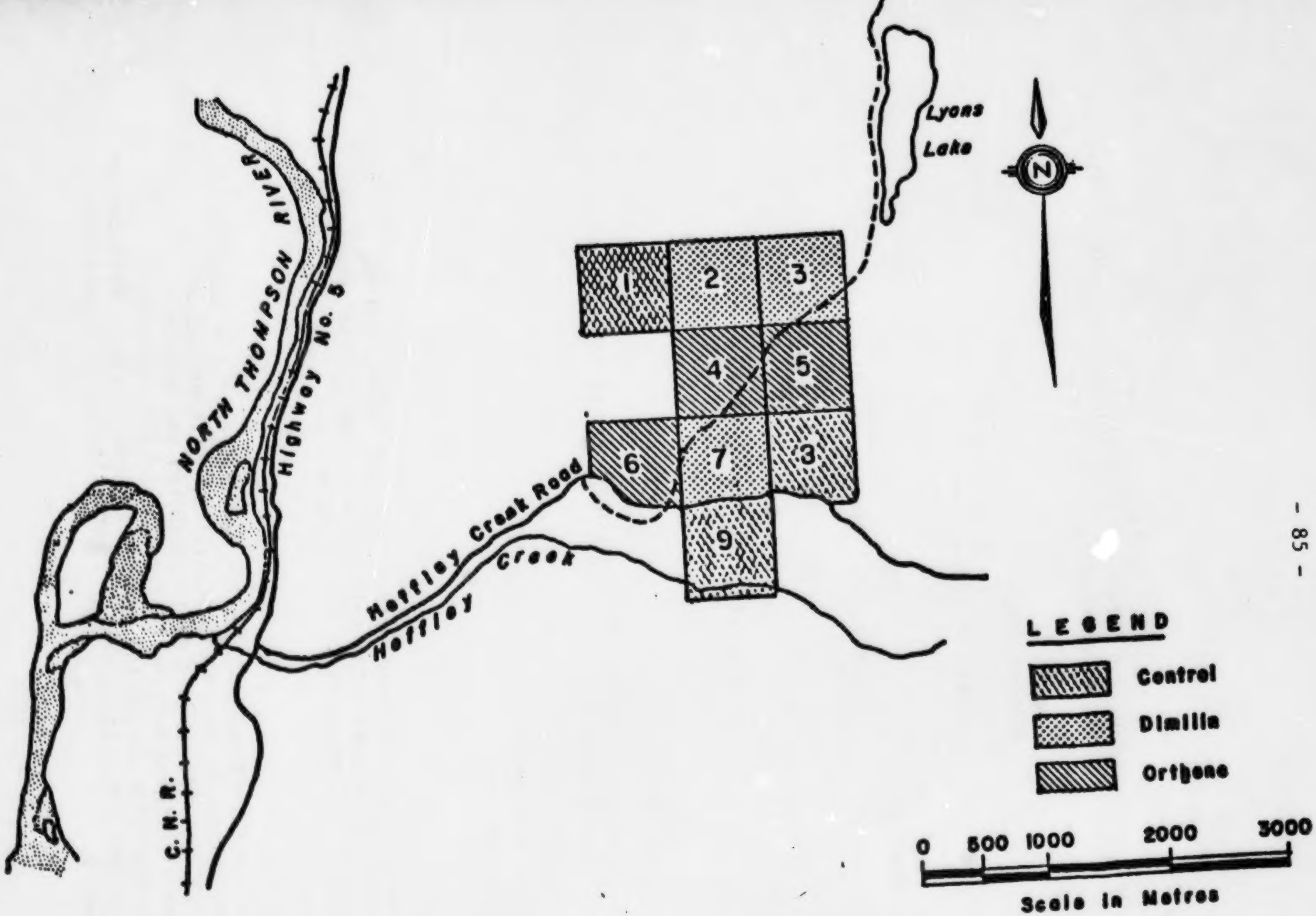

Lyons
Lake
N
NORTH THOMPSON RIVER
Highway No. 5
C. N. R.
Heffley Creek Road
Heffley Creek
1
2
3
4
5
6
7
3
9
LEGEND
Control
Dimilin
Orthene
0
500
1000
2000
3000
Scale in Metres

FIGURE 3-5 LOCATION OF SPRAY PLOTS

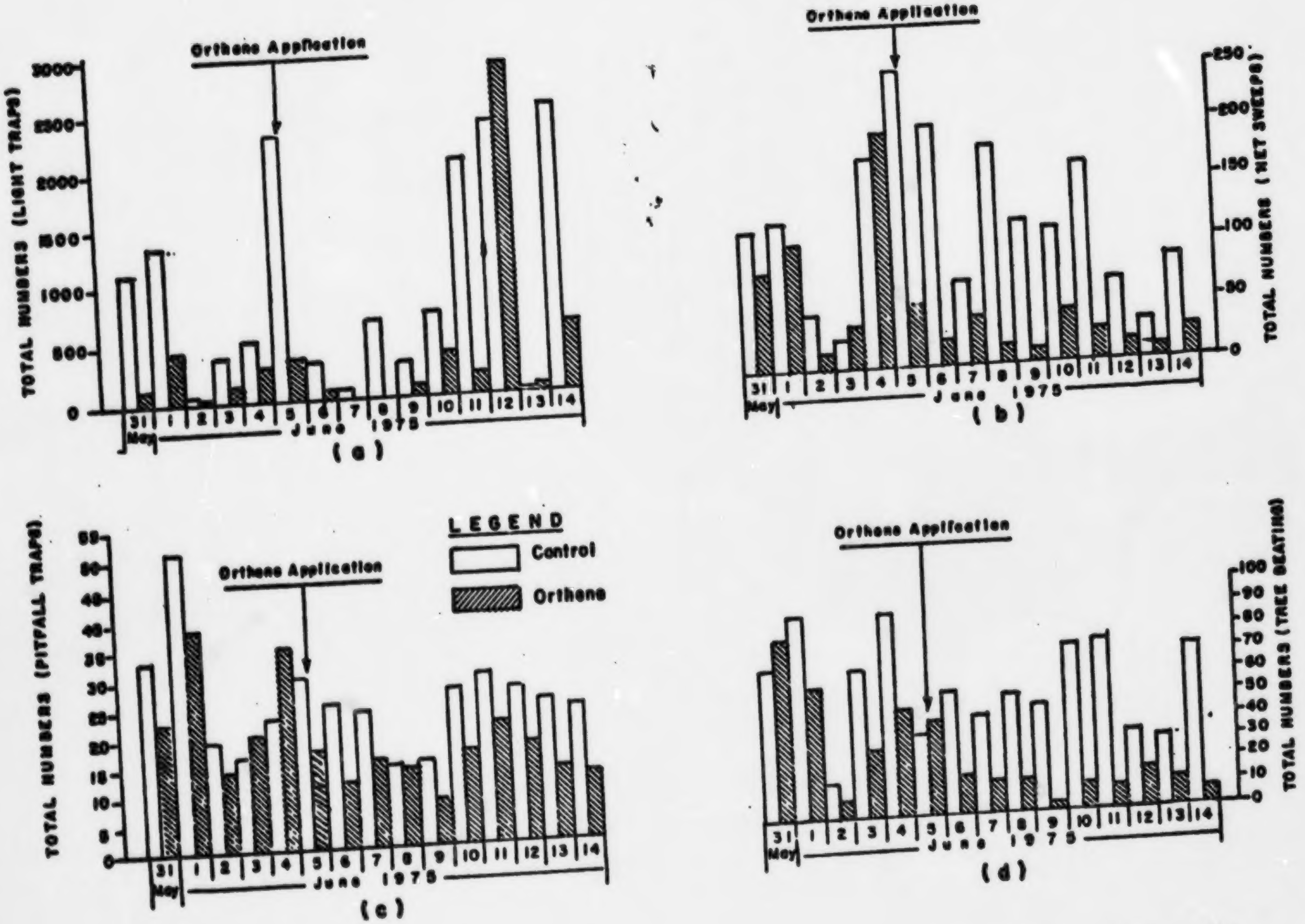


FIGURE 3-6 CHANGES IN TERRESTRIAL ARTHROPOD POPULATION DENSITIES IN ORTHENE-TREATED AND CONTROL PLOTS

APPENDIX IV

MOSQUITO CONTROL PROGRAMMES

Monitoring Study No. : 17
Monitoring Agency : Environmental Protection Service
Proponent of Project : Local Governments

PROJECT DETAILS

Location : Delta, Matsqui, Port Coquitlam, Kamploops, Tsawwassen
Purpose : Control of mosquitoes
Target species : Mosquito adults and larvae
Treatment area : 570 ha (total area)

PESTICIDE USE INFORMATION

Name of Pesticide : Abate, Malathion
Active Ingredient : As above
Rate of Application : 0.03 l abate/ha 0.3 l malathion/ha
Carrier/diluent : Water, ULV
Drift Control Agent : NA
Application Method : Back packs sprayers, fogger, fixed wing aircraft
Treatment Date : May, June, July 1975-1976

MONITORING OBJECTIVE

1. To monitor the impact of mosquito control chemicals to determine (a) the persistence of residues in air and water; and (b) the effects of the residues on fish, fish food organisms, and terrestrial arthropods.

STUDY DESIGN, LAYOUT, AND RESULTS

Refer to Figures 4-1, 4-2, 4-3 and 4-4.

SUMMARY OF RESULTS

Malathion persisted in the air for up to three hours following treatment by a truck-mounted fogger but was not detected beyond one hour when the application was conducted by a fixed wing aircraft.

Malathion persisted for three days in ponds, while in running creeks it was not detected two hours after spraying. Abate residues in water fell below the limit of detection (i.e., 1 ppb) in a very short time.

Abate did adversely affect the population of some non-target aquatic invertebrates, particularly acari, collembola, tendipedidae, diptera, ephemeroptera and odonata.

Malathion not only reduced the populations of both non-target aquatic and terrestrial invertebrates but also caused a fish kill.

CONCLUSIONS

Aerial applications of malathion contaminated water bodies in the treatment areas and the residues persisted in the air for several hours following the applications. Malathion contamination of pond water caused a fish kill. Although this chemical reduced the bee population temporarily, it had minimal impact on other non-target terrestrial arthropods.

Direct application of abate to the aquatic environment reduced the numbers of several non-target invertebrates and altered the composition of the aquatic fauna during the period of study.

REFERENCE

Wan, M.T.K. and D.M. Wilson (1976). The impact of Mosquito Control Chemicals on Selected Non-target Organisms in British Columbia. Surveillance Report, E.P.S. 5-PR-76-3.

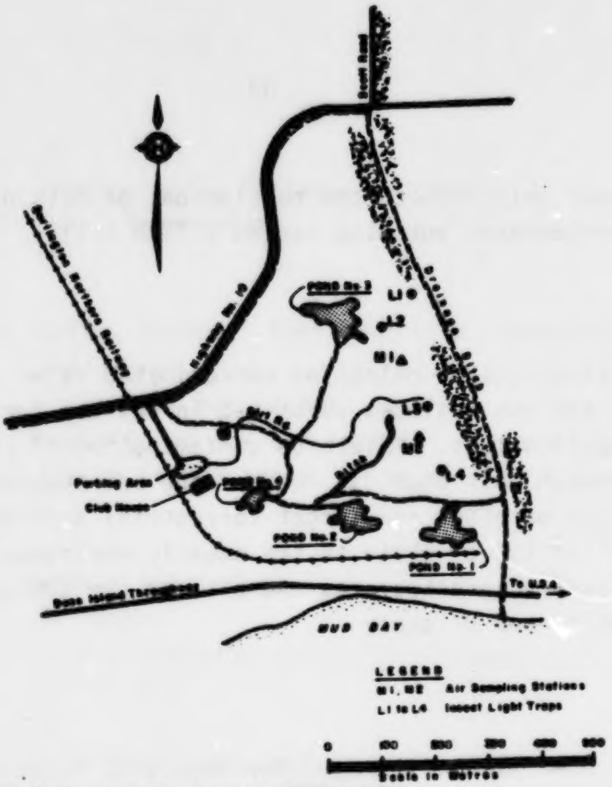

Scott Road
Burlington Northern Railroad
Highway No. 10
POND No. 3
L1
L2
M1
L3
M2
L4
Dirt Rd
Ditch
Drainage Ditch
Parking Area
Club House
POND No. 4
POND No. 2
POND No. 1
Deas Island Throughway
To U.S.A.
MUD BAY
LEGEND
M1, M2 Air Sampling Stations
L1 to L4 Insect Light Traps
0 100 200 300 400 500
Scale in Metres

FIGURE 4-1 DELTA ADULTICIDING AREA

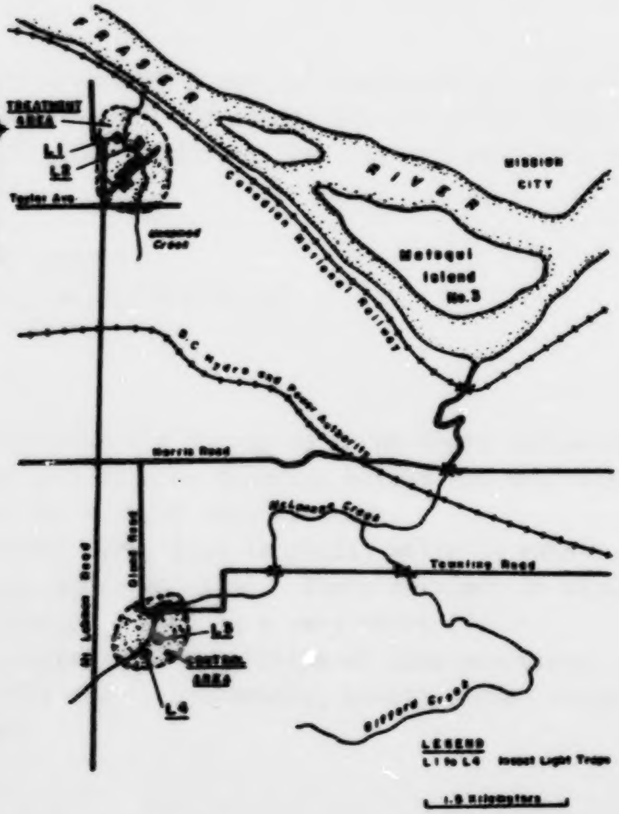

FRASER RIVER
TREATMENT AREA
L1
L2
Taylor Ave.
Creek
Canadian National Railway
MISSION CITY
Matsqui Island No.3
B.C. Hydro and Power Authority
Harris Road
Creek
Olund Road
Mt. Lehman Road
Townline Road
L3
CONTROL AREA
L4
Gifford Creek
LEGEND
L1 to L4 Insect Light Traps
1.0 Kilometers

FIGURE 4-2 MATSQUI ADULTICIDING AREA

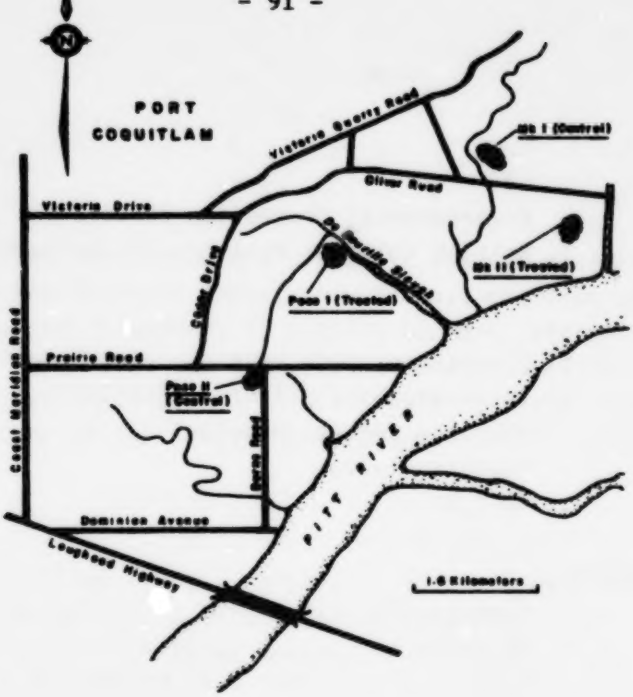

N
PORT
COQUITLAM
Victoria Quarry Road
Ob I (Control)
Oliver Road
Victoria Drive
De Boville Slough
Cedar Drive
Poco I (Treated)
Ob II (Treated)
Coast Meridian Road
Prairie Road
Poco II
(Control)
Dorset Road
PITT RIVER
Dominion Avenue
Lougheed Highway
1.6 Kilometers

FIGURE 4-3 PORT COQUITLAM LARVICIDING AREAS

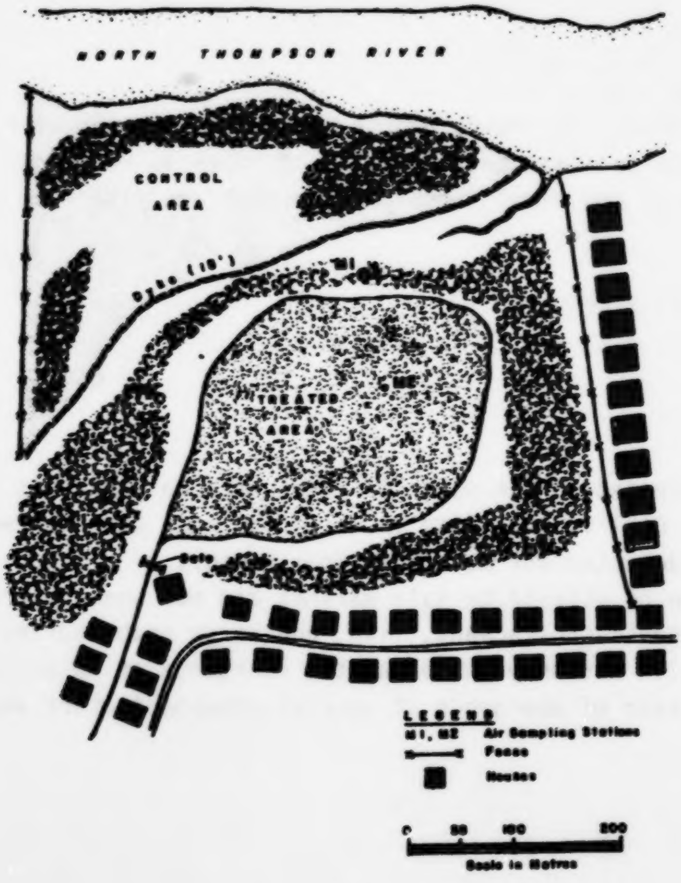

NORTH THOMPSON RIVER
CONTROL
AREA
Dyke (15')
M1
M2
TREATED
AREA
Gate
LEGEND
M1, M2 Air Sampling Stations
Fence
Houses
0
50
100
200
Scale in Metres

FIGURE 4-4 KAMLOOPS ADULTICIDING AREA

Monitoring Study No. : 18
Monitoring Agency : Environmental Protection Service
Proponent of Project : British Columbia Ministry of Agriculture

PROJECT DETAILS

Location : Tsawwassen, Fort Langley, Port Coquitlam
Purpose : To investigate efficacy of Altosid & Dimilin in Mosquito control programs
Target species : Mosquito larvae
Treatment area : 40.1 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Altosid, Dimilin
Active Ingredient : As above
Rate of Application : 0.03 kg altosid/ha 0.05 kg dimilin/ha
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Backpack sprayer, fixed wing aircraft
Treatment Date : May, June, 1976

MONITORING OBJECTIVE

1. To monitor the impact of insect growth regulators for mosquito control to determine (a) the persistence of dimilin residues in water and sediments (b) the effects of the dimilin residues on fish and fish food organisms.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 4-5, 4-6, 4-7, and 4-8.

SUMMARY OF RESULTS

Altosid was detected in the water of Tsawwassen salt marshes up to 4 days after application. Dimilin persisted in water for more than ten weeks, while in sediment it was detected for more than four months.

The application of altosid to salt marshes did not seem to produce harmful effects to zooplanktonic crustaceans, fish, and marsh crabs during the period of the study. Dimilin not only inhibited the emergence of mosquito adults but also depressed the rate of emergence of several groups of other aquatic insects.

CONCLUSION

Ground application of altosid was effective against mosquitoes and appeared to be harmless to marsh crabs, crustaceans, and fish at the Tsawwassen salt marshes. The aerial treatment of dimilin at Fort Langley, B.C., not only suppressed mosquito population but also reduced the population of zooplankton and non-target insects. Residues of insect growth regulator can persist for a variable period of time in the aquatic enviroment.

REFERENCE

Wan, M.T.K. and D.M. Wilson (1979). Impact of Insect Growth Regulators on Selected Non-target Organisms Co-existing with Mosquito Larvae. Environmental Protection Service, Regional Program Report: 79-27.

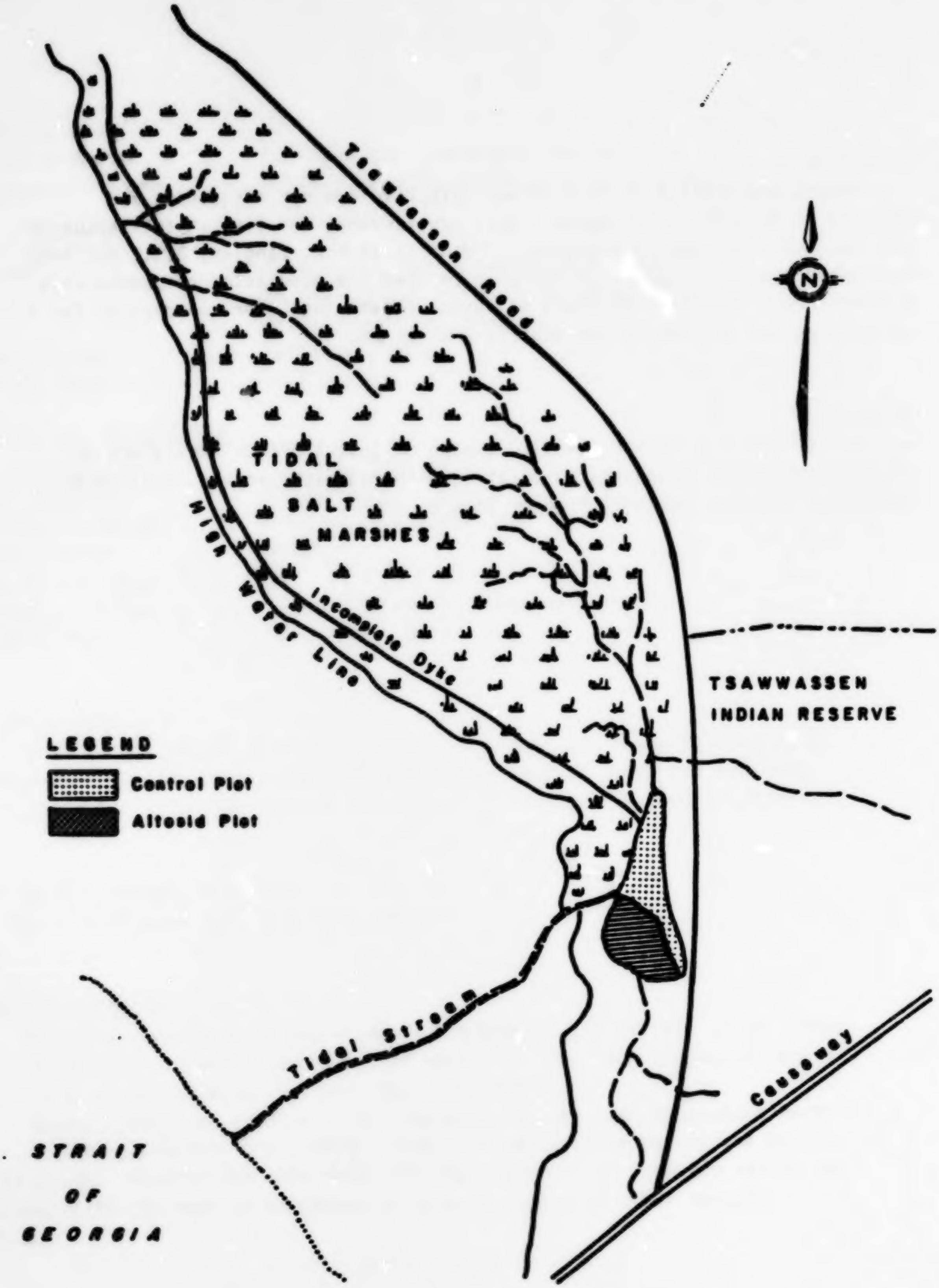

Tsawwassen Road
TIDAL SALT MARSHES
High Water Line
Incomplete Dyke
TSAWWASSEN INDIAN RESERVE
LEGEND
Control Plot
Altosid Plot
Tidal Stream
Causeway
STRAIT OF GEORGIA
N

FIGURE 4-5 LOCATION OF ALTOSID STUDY PLOTS

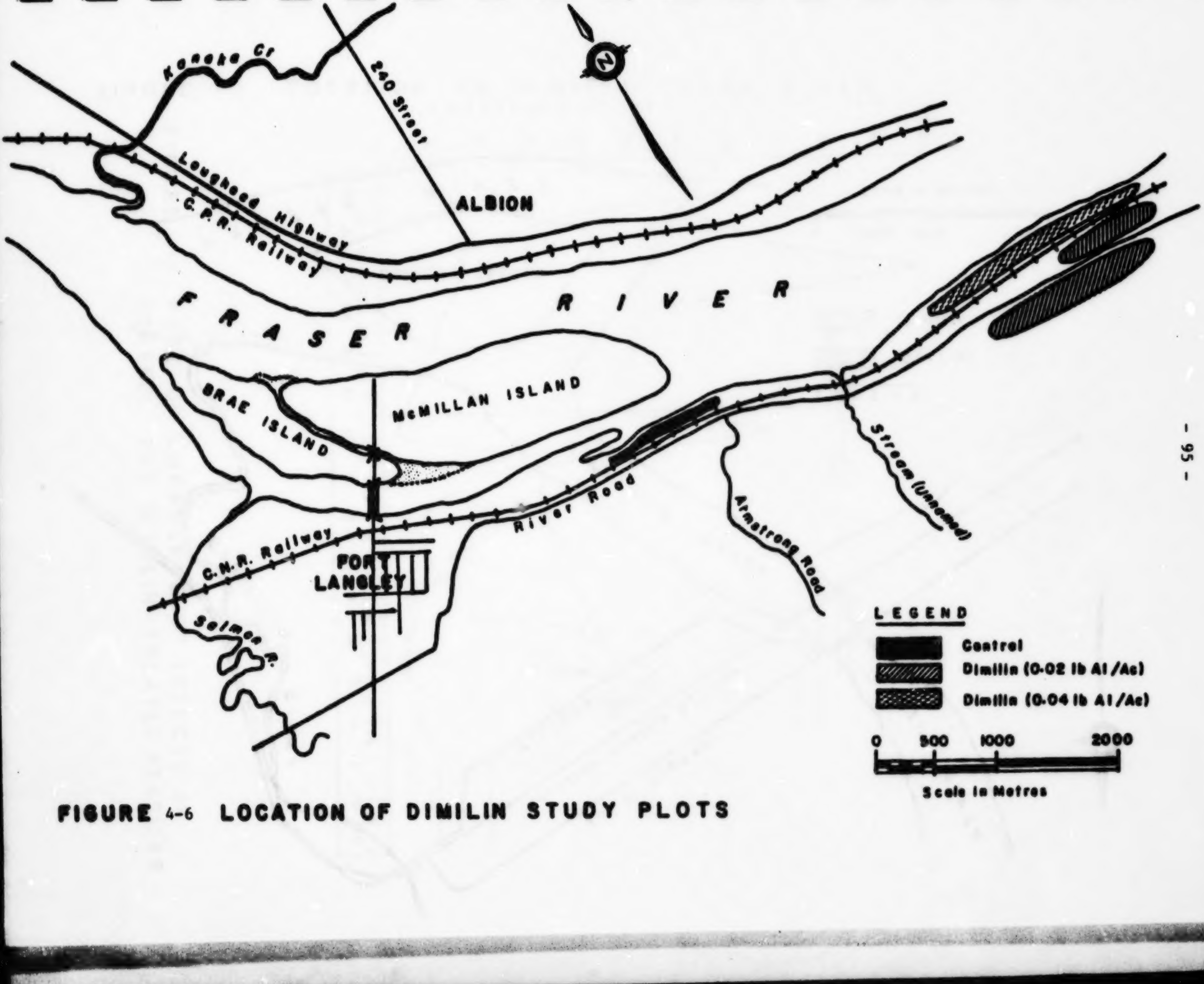

Kanaka Cr
240 Street
ALBION
Loughead Highway
C.P.R. Railway
FRASER RIVER
BRAE ISLAND
McMILLAN ISLAND
FORT LANGLEY
C.N.R. Railway
Salmon R.
River Road
Armstrong Road
Stream (Unnamed)
N
LEGEND
Control
Dimilin (0.02 lb AI/Ac)
Dimilin (0.04 lb AI/Ac)
0
500
1000
2000
Scale in Metres

FIGURE 4-6 LOCATION OF DIMILIN STUDY PLOTS

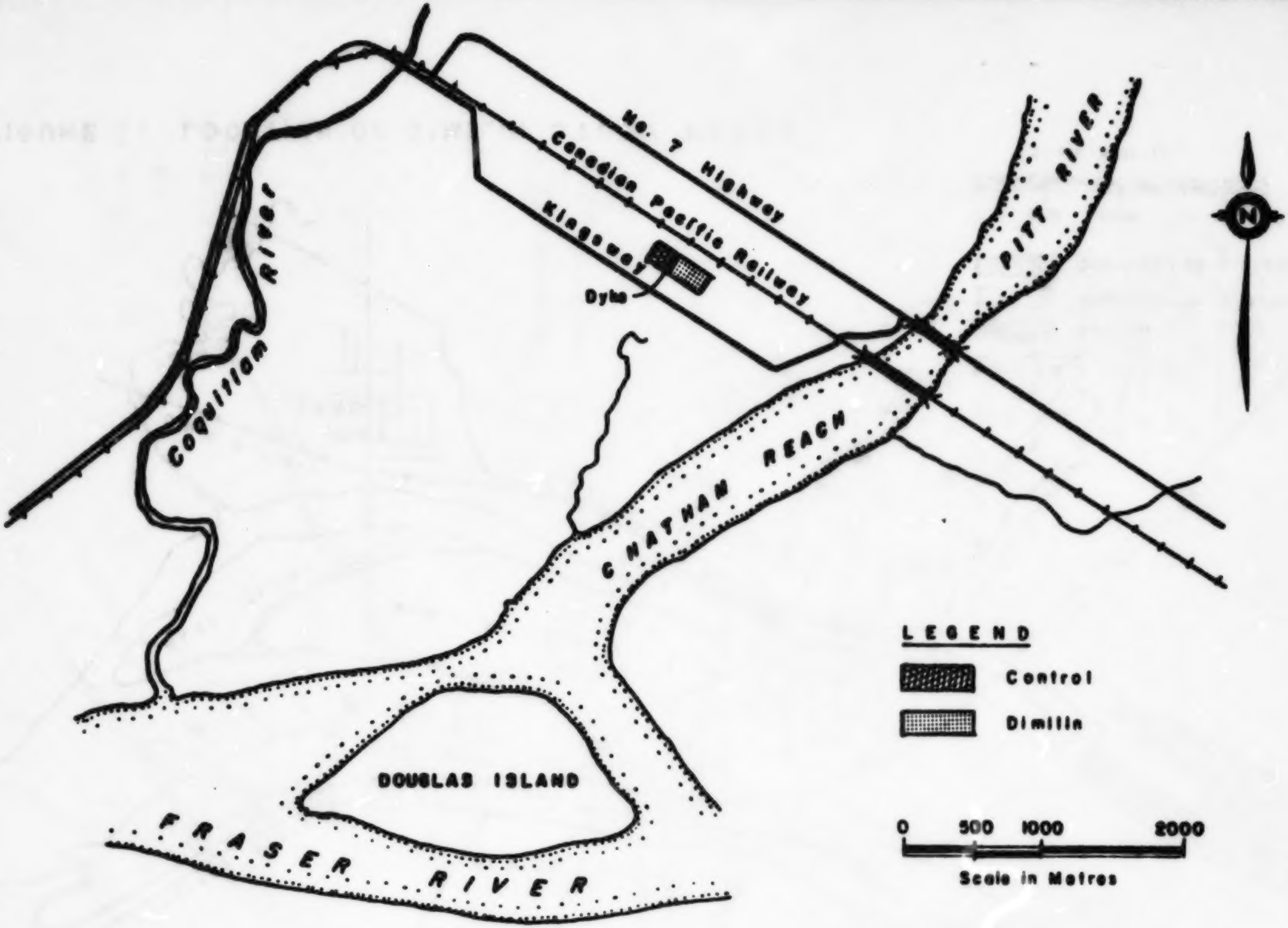

No. 7 Highway
Canadian Pacific Railway
Kingsway
Dyke
Coquitlam River
PITT RIVER
CHATHAM REACH
DOUGLAS ISLAND
FRASER RIVER
N
LEGEND
Control
Dimilin
0
500
1000
2000
Scale in Metres

FIGURE 4-7 LOCATION OF DIMILIN STUDY PLOTS

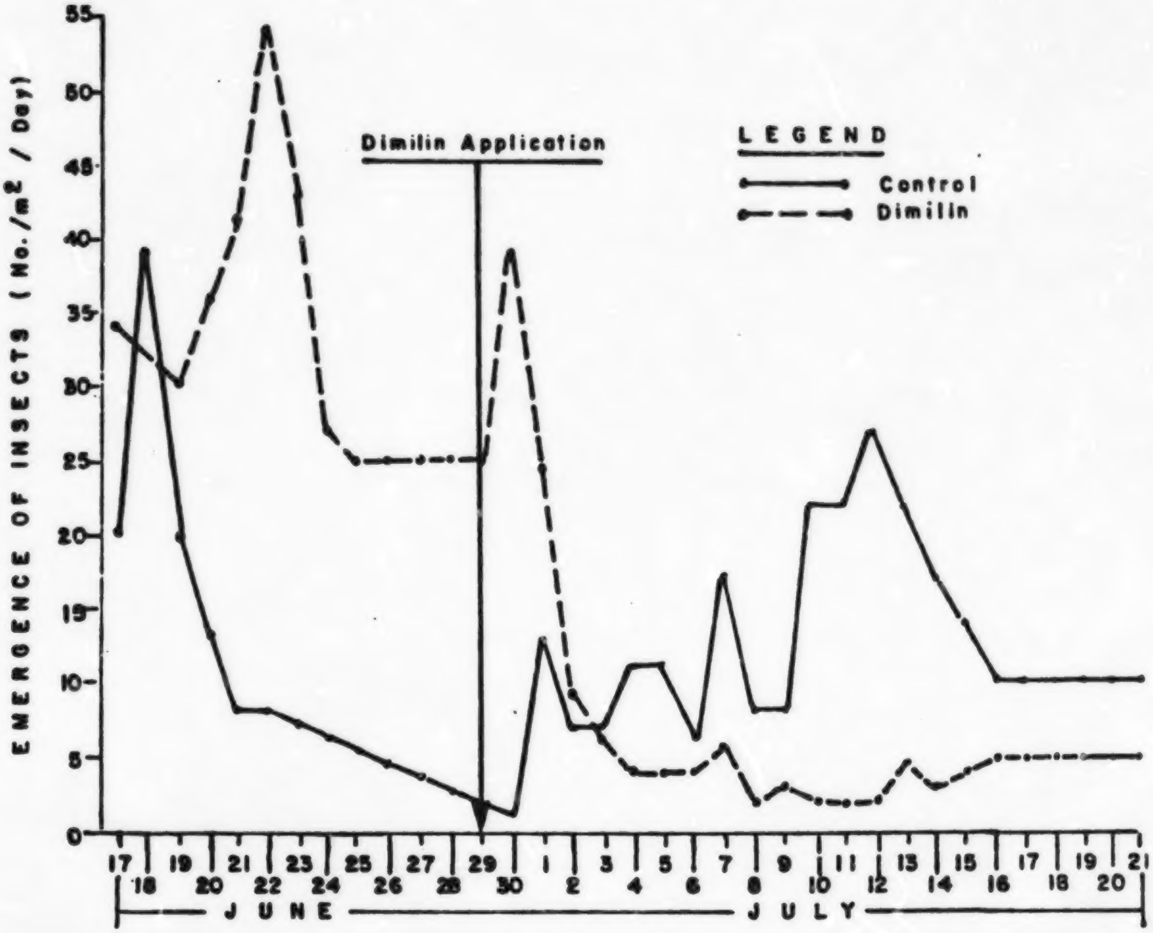


FIGURE 4-8 RATE OF EMERGENCE OF INSECTS IN CONTROL AND DIMILIN-TREATED STATIONS

APPENDIX V

AGRICULTURAL-URBAN PEST CONTROL PROGRAMMES

Monitoring Study No.	:	19
Monitoring Agency	:	Environmental Protection Service
Proponent of Project	:	Industries, farmers, private individuals

PROJECT DETAILS

Location	:	Sumas Prairie
Purpose	:	Weeds/pest control
Target species	:	Agricultural/Industrial Weeds
Treatment area	:	100 sq. km

PESTICIDE USE INFORMATION

Name of Pesticide	:	Agricultural/Industrial Pesticides
Active Ingredient	:	Organo-chlorine and other pesticides
Rate of Application	:	Manufacturer's recommended rate
Carrier/diluent	:	Water
Drift Control Agent	:	NA
Application Method	:	Tractor mounted boom sprays, power hose
Treatment Date	:	NA

MONITORING OBJECTIVES

1. To determine the levels of selected pesticide residues (organo-chlorines, triazines, uracil, urea) in the sediment of the Sumas River system:
2. To obtain preliminary data on the pesticide residues found in coarse fish in the Sumas River.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 5-1 and 5-2.

SUMMARY OF RESULTS

DDT, DDD, thiodan, atrazine, simazine, and tebuthiuron were occasionally found in low levels at various concentrations (i.e., 2-94,000 ppb) in the sediments of the Sumas River system. Apart from the organo-chlorine pesticides, residue levels of other pesticides appeared to be related to seasonal use of the various materials.

Organo-chlorine and other pesticide residues were found in the muscle tissues of coarse fish in the Sumas Lake Drainage Canal.

CONCLUSIONS

Low levels of organo-chlorine and other pesticides were found in the sediments of the Sumas River. There was evidence to suggest that the occurrence of pesticide residues in the sediment was related to the timing of spray application by the agricultural and industrial communities in the Sumas Prairie. As well, there was indication of pesticide residues occurring in fish.

REFERENCE

Wan, M.T.K. (1980). Effect of Urban-agricultural Pesticide Use on Residue levels in the Sediments of the Drainage Systems of Lulu Island and the Sumas Prairie in the Lower Fraser Valley, British Columbia, Canada. E.P.S. Memo Report 1980.

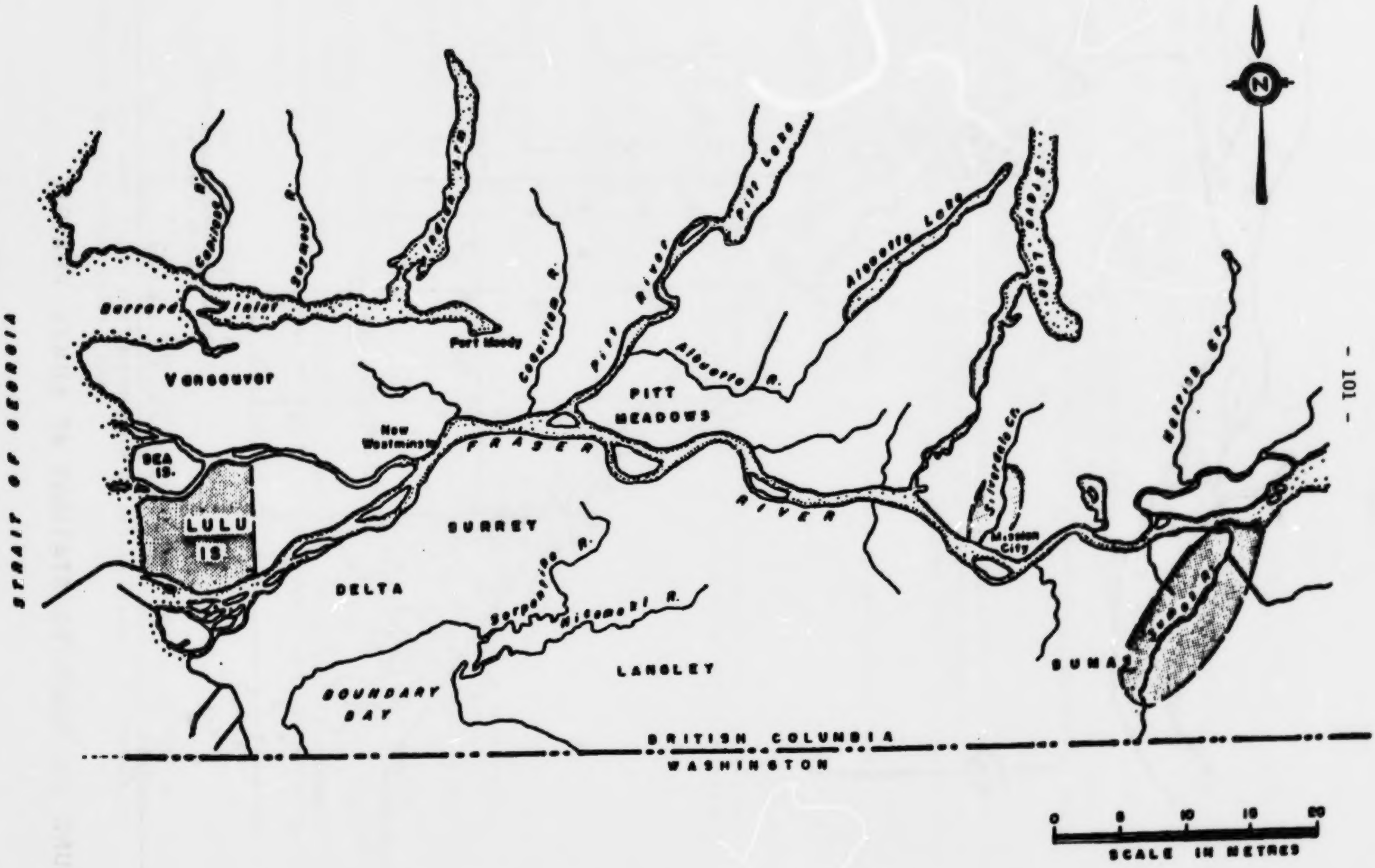

STRAIT OF GEORGIA
Burrard Inlet
Capilano R.
Seymour R.
Indian Arm
Port Moody
Vancouver
Coquitlam R.
Pitt River
Pitt Lake
Alouette R.
Alouette Lake
Stave Lake
PITT MEADOWS
New Westminster
FRASER RIVER
SEA IS.
LULU IS.
SURREY
DELTA
Serpentine R.
Nicomekl R.
LANGLEY
BOUNDARY BAY
Silverdale Cr.
Mission City
SUMAS
BRITISH COLUMBIA
WASHINGTON
0
5
10
15
20
SCALE IN METRES
N

FIGURE 5-1 LOCATION OF STUDY AREAS OF SUMAS PRAIRIE

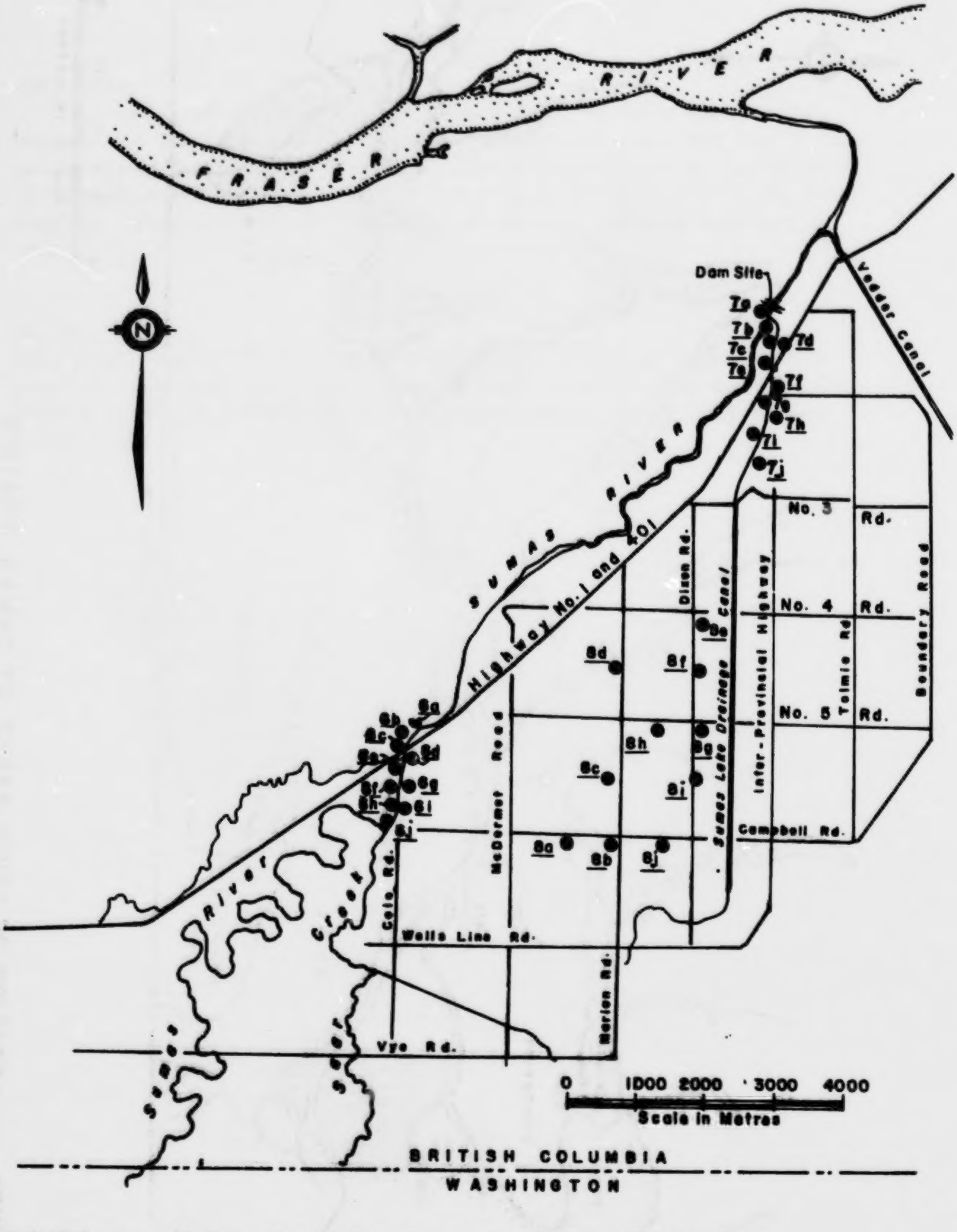

FRASER RIVER
N
Dam Site
7a
7b
7c
7d
7e
7f
7g
7h
7i
7j
Vedder Canal
SUMAS RIVER
Highway No. 1 and 401
No. 3 Rd.
No. 4 Rd.
No. 5 Rd.
Dixon Rd.
Sumas Lake Drainage Canal
Inter-Provincial Highway
Tolmie Rd
Boundary Road
6a
6b
6c
6d
6e
6f
6g
6h
6i
6j
8a
8b
8c
8d
8e
8f
8g
8h
8i
8j
McDermot Road
Cole Rd.
Campbell Rd.
Wells Line Rd.
Marion Rd.
Vye Rd.
Sumas River
Saar Creek
0
1000
2000
3000
4000
Scale in Metres
BRITISH COLUMBIA
WASHINGTON

FIGURE 5-2 SAMPLING STATIONS AT SUMAS PRAIRIE

Monitoring Study No.	:	20
Monitoring Agency	:	Environmental Protection Service
Proponent of Project	:	Industries, farmers, private individuals

PROJECT DETAILS

Location	:	Lulu Island (Richmond areas)
Purpose	:	Weeds/pest control
Target species	:	Weeds in agricultural/industrial/residential areas
Treatment area	:	150 sq. km

PESTICIDE USE INFORMATION

Name of Pesticide	:	Agricultural/Industrial Pesticides
Active Ingredient	:	Organo-chlorine and other pesticides
Rate of Application	:	Manufacturer's recommended rate
Carrier/diluent	:	Water
Drift Control Agent	:	NA
Application Method	:	Backpack sprayer, boom sprayers, power hose
Treatment Date	:	NA

MONITORING OBJECTIVE

1. To determine the levels of selected pesticide residues (organo-chlorines, triazines, uracil, urea) in the sediment of a controlled drainage system (Lulu Island)

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 5-3 and 5-4.

SUMMARY OF RESULTS

DDT, DDD, thiodan, atrazine, and bromacil were occasionally detected in the sediments of Richmond pumphouses and residential ditches. Increasing levels of residues of DDT, DDD, DDE (ie., 30-106,000 ppb) were found in the sediments of the residential ditches as the season progressed.

CONCLUSION

There was no evidence to suggest that low levels of pesticide residues were transported via the drainage ditches to the pumphouses and discharged to the Fraser River.

REFERENCE

Wan, M.T.K. (1980). Effect of Urban-agricultural Pesticide Use on Residue Levels in the Sediments of the Drainage Systems of Lulu Island and the Sumas Prairie in the Lower Fraser Valley, British Columbia, Canada. Environmental Protection Service, Memo Report, 1980.

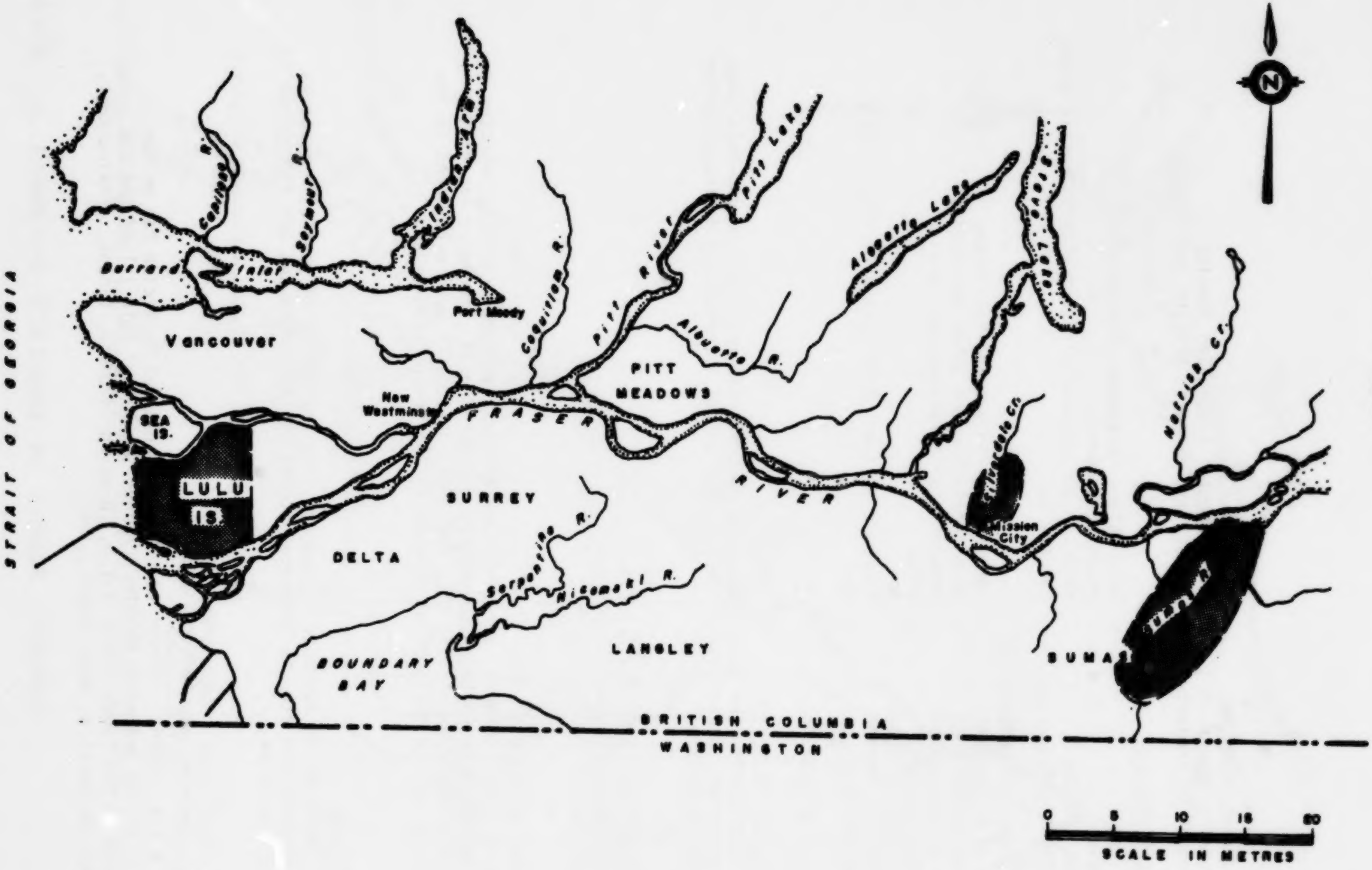

N
STRAIT OF GEORGIA
Burrard Inlet
Capilano R.
Seymour R.
Indian Arm
Port Moody
Vancouver
Coquitlam R.
Pitt River
Pitt Lake
Alouette Lake
Alouette R.
Stave Lake
PITT MEADOWS
New Westminster
FRASER RIVER
SEA IS.
LULU IS.
SURREY
DELTA
Serpentine R.
Nicomekl R.
LANGLEY
BOUNDARY BAY
Mission City
Norrish Cr.
SUMAS
BRITISH COLUMBIA
WASHINGTON
0
5
10
15
20
SCALE IN METRES

FIGURE 5-3 LOCATION OF STUDY AREAS OF LULU ISLAND

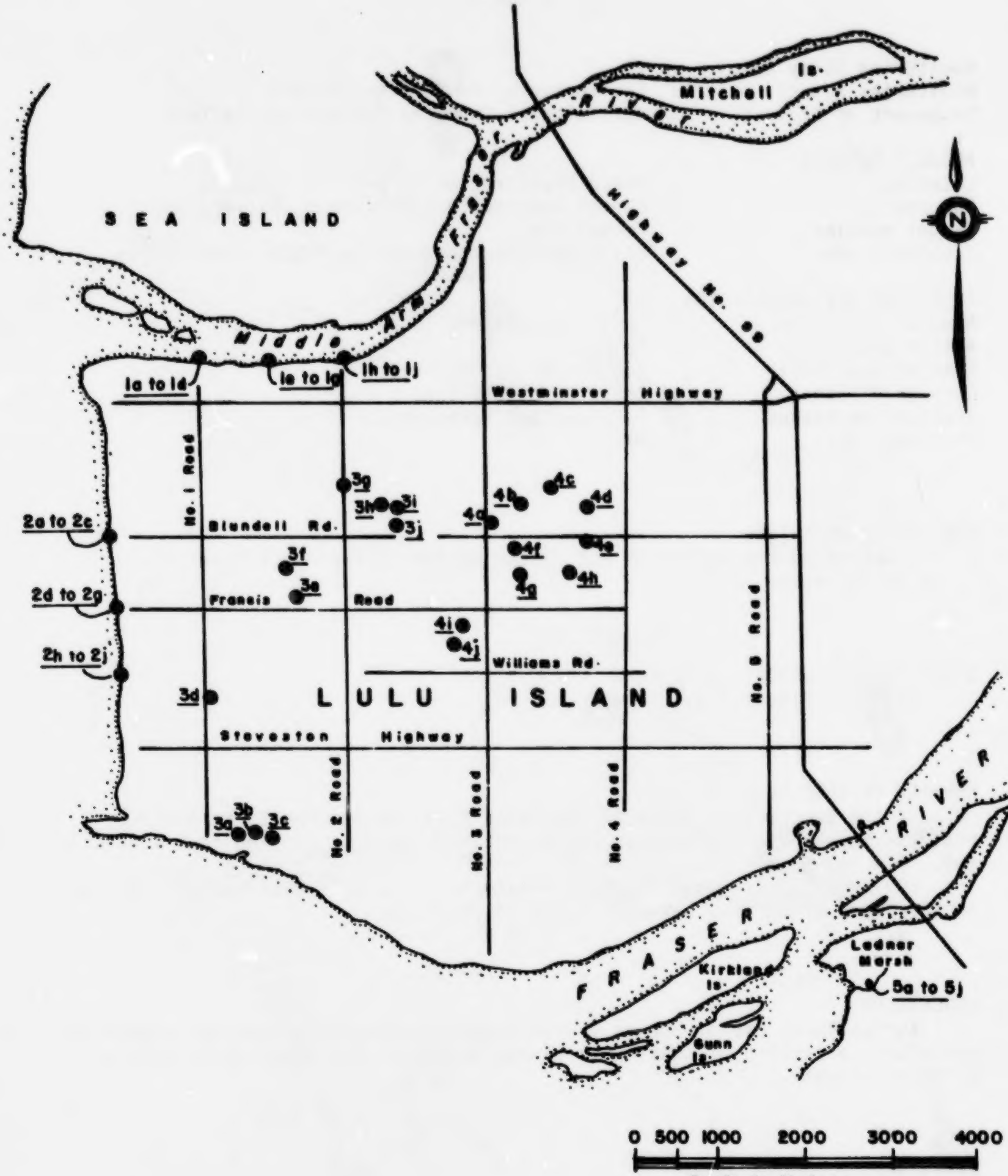

SEA ISLAND
Mitchell Is.
Fraser River
Middle Arm
Highway No. 99
N
1a to 1d
1e to 1g
1h to 1j
Westminster Highway
No. 1 Road
Blundell Rd.
Francis Road
Williams Rd.
Steveston Highway
No. 2 Road
No. 3 Road
No. 4 Road
No. 5 Road
2a to 2c
2d to 2g
2h to 2j
3a
3b
3c
3d
3e
3f
3g
3h
3i
3j
4a
4b
4c
4d
4e
4f
4g
4h
4i
4j
LULU ISLAND
FRASER RIVER
Kirkland Is.
Gunn Is.
Ladner Marsh
5a to 5j
0 500 1000 2000 3000 4000
Scale in Metres

FIGURE 5-4 SAMPLING STATIONS ON LULU ISLAND

Monitoring Study No. : 21
Monitoring Agency : Environmental Protection Service
Proponent of Project : Agricultural Chemical Industries, Farmers

PROJECT DETAILS

Location : Peace River region of British Columbia
Purpose : Cereal seed protection (wheat, barley, oats)
Target species : Fungal rot
Treatment area : Grain growing areas of the Peace River region

PESTICIDE USE INFORMATION

Name of Pesticide : Hexachlorobenzene (HCB)
Active Ingredient : As above
Rate of Application : 1-2 oz per bushel seed
Carrier/diluent : Inert dust particles
Application Method : Combine seed spreaders
Treatment Date : NA

MONITORING OBJECTIVE

1. To determine the extent of HCB contamination in the Peace River grain growing region

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figure 5-5.

SUMMARY OF RESULTS

Of the twenty-four areas in the Peace River region monitored for HCB residues in the soil, six areas had detectable residues ranging from 1.3 to 2.2 ppb.

HCB is no longer used for seed treatment. The last application occurred in the Peace River area between 10 and 15 years ago.

CONCLUSION

Agricultural use of HCB as a seed treatment fungicide does not appear to constitute a lasting or continuous source of HCB in the Peace River area of British Columbia.

REFERENCE

Wilson, D.M. and M.T.K. Wan (1981). Hexachlorobenzene - Sources of Envronmental Contamination in British Columbia. Environmental Protection Service Regional Program Report: 81-12.

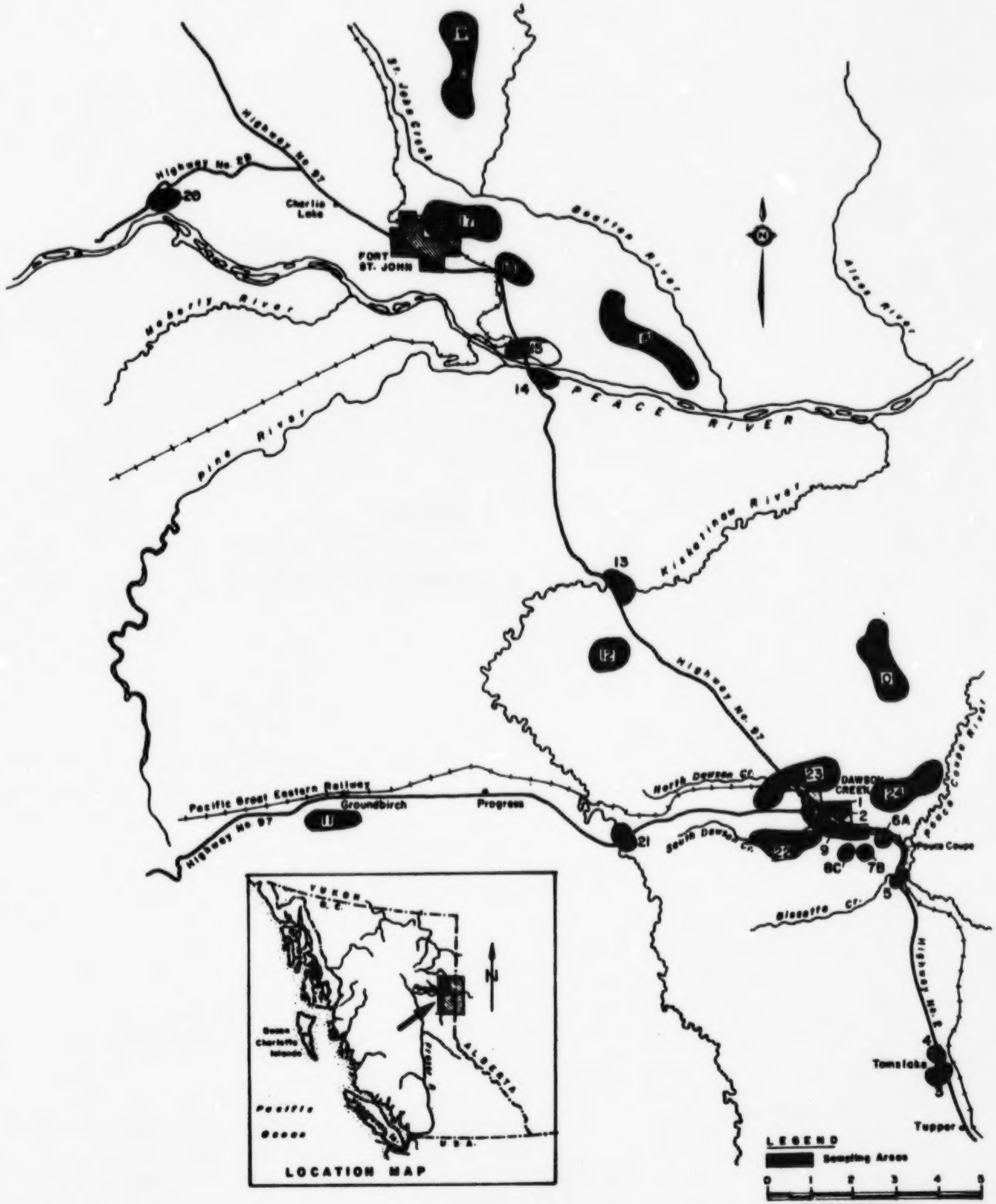

Highway No. 29
Highway No. 97
20
Charlie Lake
St. John Creek
FORT ST. JOHN
17
Beatton River
Alces River
N
Moberly River
15
14
PEACE RIVER
Pine River
Kiskatinaw River
13
12
Highway No. 97
Pacific Great Eastern Railway
Groundbirch
Progress
Highway No 97
11
21
North Dawson Cr.
South Dawson Cr.
23
DAWSON CREEK
24
1
2
6A
22
9
8C
7B
Pouce Coupe
Pouce Coupe River
5
Bissette Cr.
Highway No. 2
4
Tomslake
3
Tupper
YUKON
B.C.
N
Queen Charlotte Islands
Pacific Ocean
ALBERTA
U.S.A.
LOCATION MAP
LEGEND
Sampling Areas
0
1
2
3
4
5
Scale in Kilometres

FIGURE 5-5 HEXACHLOROBENZENE SURVEY IN THE PEACE RIVER REGION, B. C.

APPENDIX VI

AQUATIC PEST CONTROL PROGRAMMES

Monitoring Study No. : 22
Monitoring Agency : Environmental Protection Service
Proponent of Project : British Columbia Department of Lands, Forests, and Water Resources (Water Investigation Branch)

PROJECT DETAILS

Location : Vernon Arm of Okanagan Lake
Purpose : Aquatic weed control
Target species : Control of water milfoil
Treatment area : 0.1 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Paraquat, dichlobenil, diquat
Active Ingredient : As above
Rate of Application : Combination herbicides of up to 18.7 kg/ha
Carrier/diluent : NA
Drift Control Agent : NA
Application Method : Backpack hand pump sprayer
Treatment Date : May 28, 1974

MONITORING OBJECTIVE

1. To monitor the impact of diquat, paraquat, and dichlobenil on non-target macro-invertebrates and plankton.

STUDY DESIGN, LAYOUT, AND RESULTS

Refer to Figures 6-1 and 6-2.

SUMMARY OF RESULTS

Numbers of invertebrates in the treated plots remained constant while numbers in the control plot increased during the 49 day sampling period. Continuing growth of aquatic plants provided suitable habitat for population expansions of herbivorous invertebrates primarily diptera (tendipedidae), ephemeroptera, and trichoptera. Changes in the dominant habitat from weed kill in treated plots may have prevented population increases during the post-treatment period.

Planktonic communities were also unaffected although changes in numbers of individuals were demonstrated. These changes were considered to be the result of seasonal variations rather than a delayed effect from herbicide treatment.

CONCLUSION

Application of bi-pyridylium and nitrile herbicides to 10 x 15 meter enclosures in Vernon Arm of Okanagan Lake did not appear to have an adverse effect on either the community diversity or total numbers of aquatic invertebrates.

REFERENCE

Wilson, D.M. and M.T.K. Wan (1975). Effects of Some Aquatic Weed Control Chemicals on Invertebrates and Plankton in Vernon Arm of Okanagan Lake. Surveillance Report E.P.S. 5-PR-75-1.

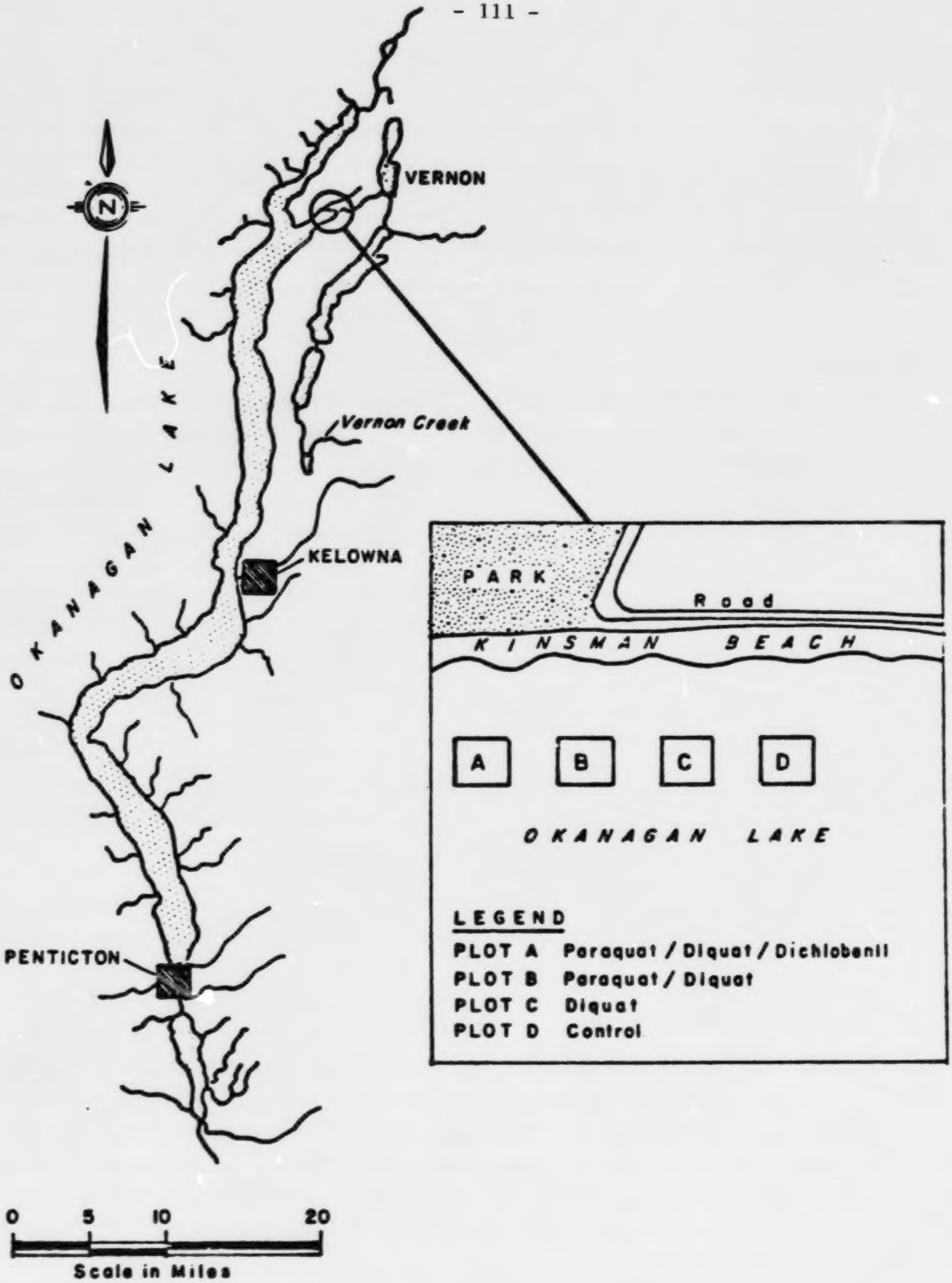

VERNON
OKANAGAN LAKE
Vernon Creek
KELOWNA
PENTICTON
N
0
5
10
20
Scale in Miles
PARK
Road
KINSMAN BEACH
A
B
C
D
OKANAGAN LAKE
LEGEND
PLOT A Paraquat / Diquat / Dichlobenil
PLOT B Paraquat / Diquat
PLOT C Diquat
PLOT D Control

FIGURE 6-1 LOCATION OF VERNON ARM ON OKANAGAN LAKE SYSTEM AND SKETCH OF EXPERIMENTAL LAYOUT.

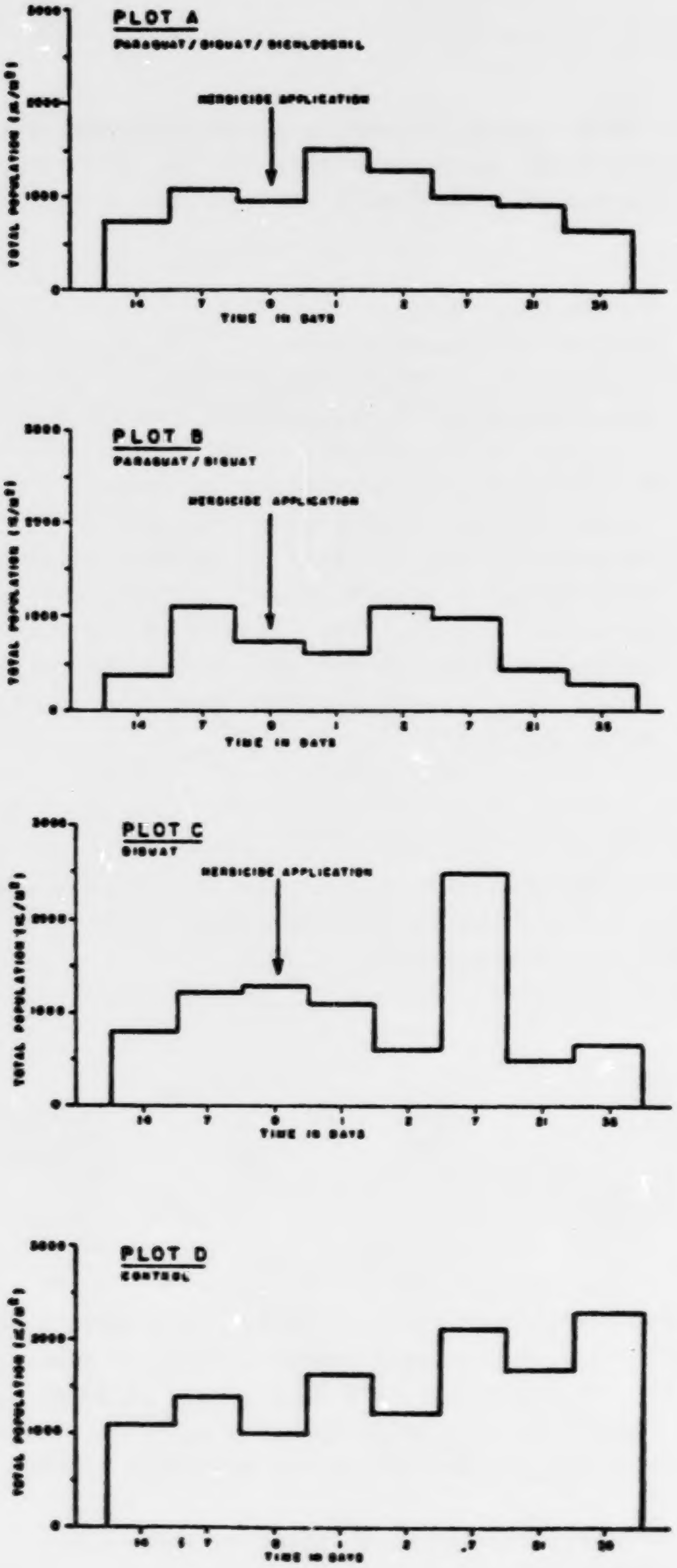


FIGURE 6-2 EFFECTS OF AQUATIC HERBICIDES ON TOTAL INVERTEBRATE NUMBERS

Monitoring Study No. : 23
Monitoring Agency : Environmental Protection Service/Department of Fisheries and Oceans
Proponent of Project : Cultus Lake Park Board

PROJECT DETAILS

Location : Cultus Lake, B.C.
Purpose : Control of Swimmer's Itch
Target species : Snail hosts of Trichabilharzia sp
Treatment area : Selected recreational beaches

PESTICIDE USE INFORMATION

Name of Pesticide : Copper Sulphate ($CuSO_4$ SH_2O)
Active Ingredient : As above
Rate of Application : 97.65 kg/ha
Carrier/diluent : NA
Drift Control Agent : NA
Application Method : Marmal Scoop aboard a powered raft
Treatment Date : March 20, 1978

MONITORING OBJECTIVES

1. To monitor the extent of contamination in Cultus Lake sediment and water following copper sulphate applications to specific areas;
2. To monitor the effect of $CuSO_4$ lake treatment on fish;
3. To determine the impact of $CuSO_4$ treatment on the Swimmer's Itch problem.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 6-3, 6-4, 6-5, and 6-6.

SUMMARY OF RESULTS

Elevated dissolved copper levels were found in Cultus Lake surface and bottom waters (0.02-0.04 mg/l and 0.02-0.13 mg/l respectively) for several hours following the application of copper sulphate at the rate of 97.65 kg/ha. These levels approached the known LC_{50} of fish (0.02-0.516 mg/l) but their mortality and sub-lethal effects was neither proven nor disproven by this study.

Sediments in areas historically treated with copper sulphate were contaminated with copper to levels well above background values.

No significant differences in Swimmer's Itch incidence levels were noted between the treatment and non-treatment years, and therefore it was concluded that copper sulphate has not been effective in reducing Swimmer's Itch at Cultus Lake.

CONCLUSIONS

Although fish studies were inconclusive, sediment monitoring indicated that sediments in treatment areas had been and would continue to be contaminated with copper for an indefinite time period. In addition, the post-treatment water column was contaminated with dissolved copper for a short time, to levels near the LC_{50} of fish.

Questionnaire studies indicated no significant reduction in the incidence of Swimmer's Itch, despite ($CuSO_4$) molluscicide treatments. The study further showed that the itch had little effect in decreasing tourist demand on the lake system, and the application of copper sulphate to this lake was recommended to be discontinued.

REFERENCE

Wan, M.T.K., B. Pearce, and J. Truscott (1982). Impact of Copper Sulphate Molluscicide Treatments on Cultus Lake, B.C. Environmental Protection Service Regional Program Report: No. 82-08, (In Press).

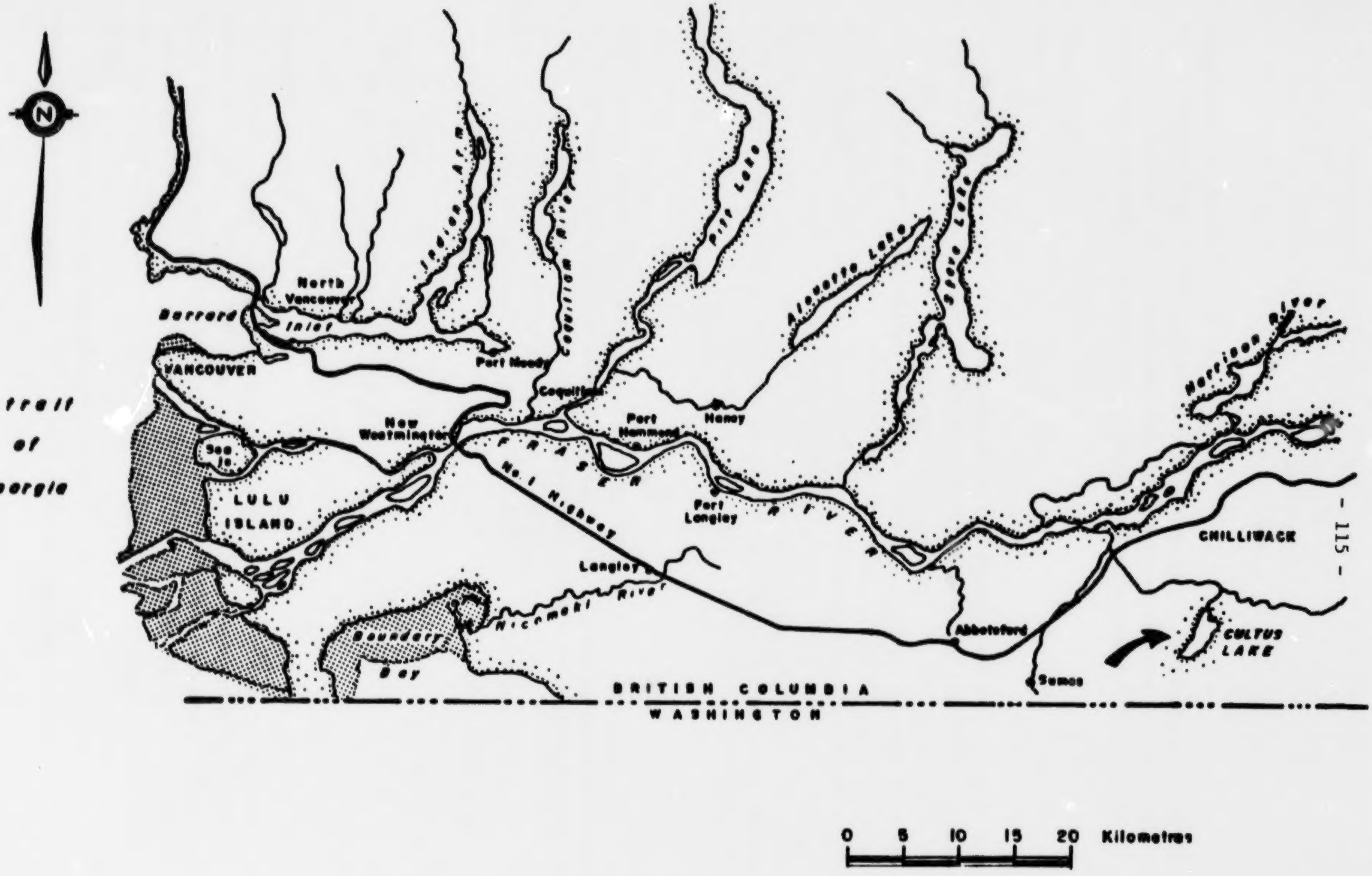

N
Strait of Georgia
Burrard Inlet
North Vancouver
Indian Arm
Coquitlam River
Pitt Lake
Alouette Lake
Stave Lake
Harrison River
VANCOUVER
Port Moody
Coquitlam
New Westminster
Port Hammond
Haney
Sea Is.
LULU ISLAND
FRASER RIVER
No. 1 Highway
Port Langley
Langley
Nicomekl River
Boundary Bay
Abbotsford
Sumas
CHILLIWACK
CULTUS LAKE
BRITISH COLUMBIA
WASHINGTON
0
5
10
15
20
Kilometres

FIGURE 6-3 LOCATION MAP OF CULTUS LAKE

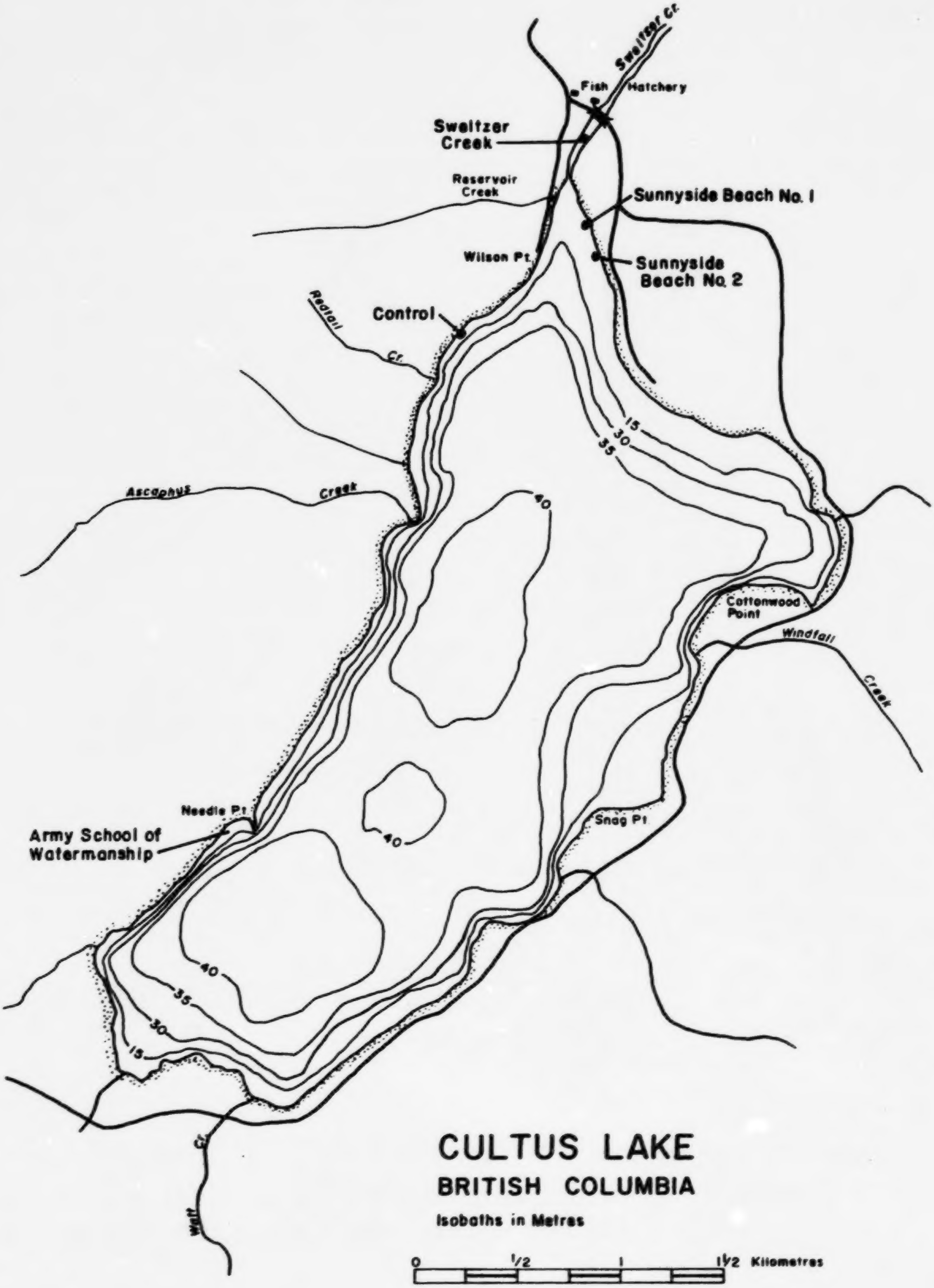

Sweltzer Cr.
Fish Hatchery
Sweltzer Creek
Reservoir Creek
Sunnyside Beach No. 1
Wilson Pt.
Sunnyside Beach No. 2
Redtail Cr.
Control
15
30
35
Ascaphus Creek
40
Cottonwood Point
Windfall Creek
Needle Pt.
Army School of Watermanship
Snag Pt.
40
40
35
30
15
Watt Cr.
CULTUS LAKE
BRITISH COLUMBIA
Isobaths in Metres
0
1/2
1
1 1/2 Kilometres

FIGURE 6-4 CULTUS LAKE SEDIMENT AND WATER SAMPLING STATIONS

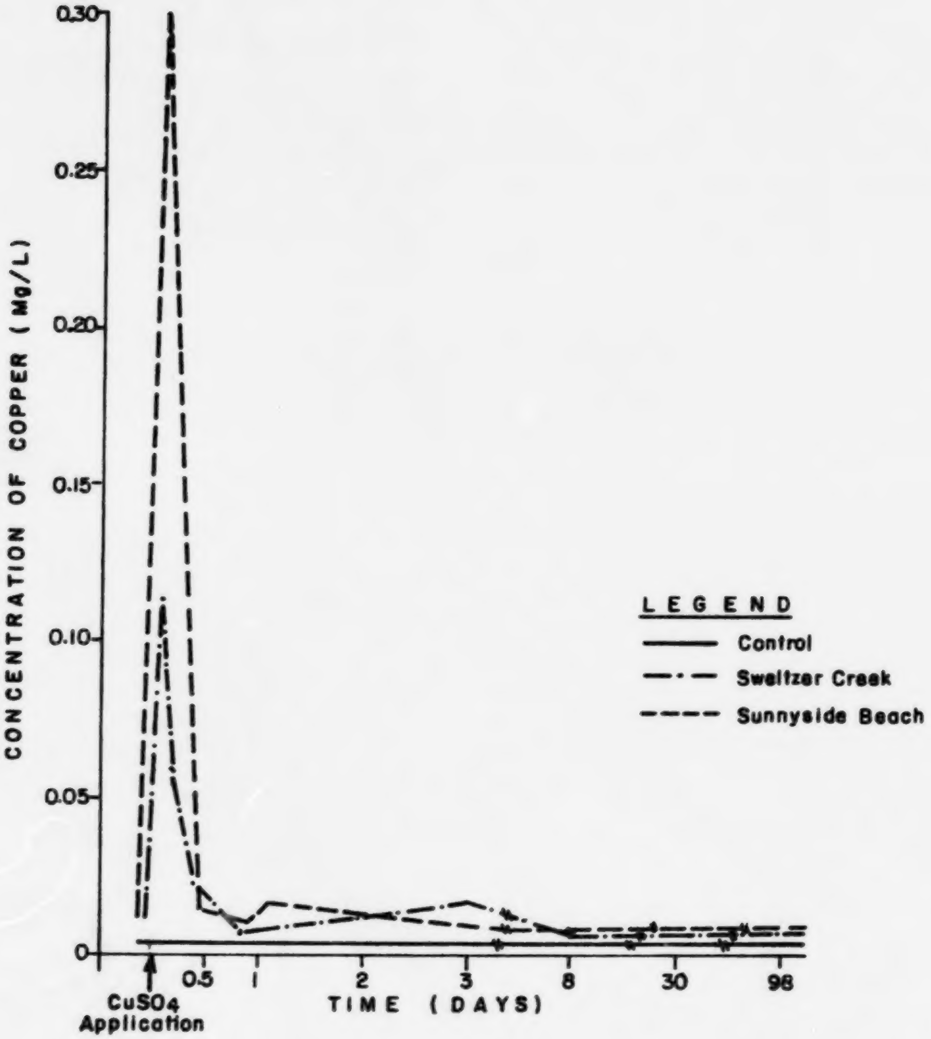


FIGURE 6-5 DISSOLVED COPPER IN BOTTOM WATER OF CULTUS LAKE AND SWELTZER CREEK (1978)

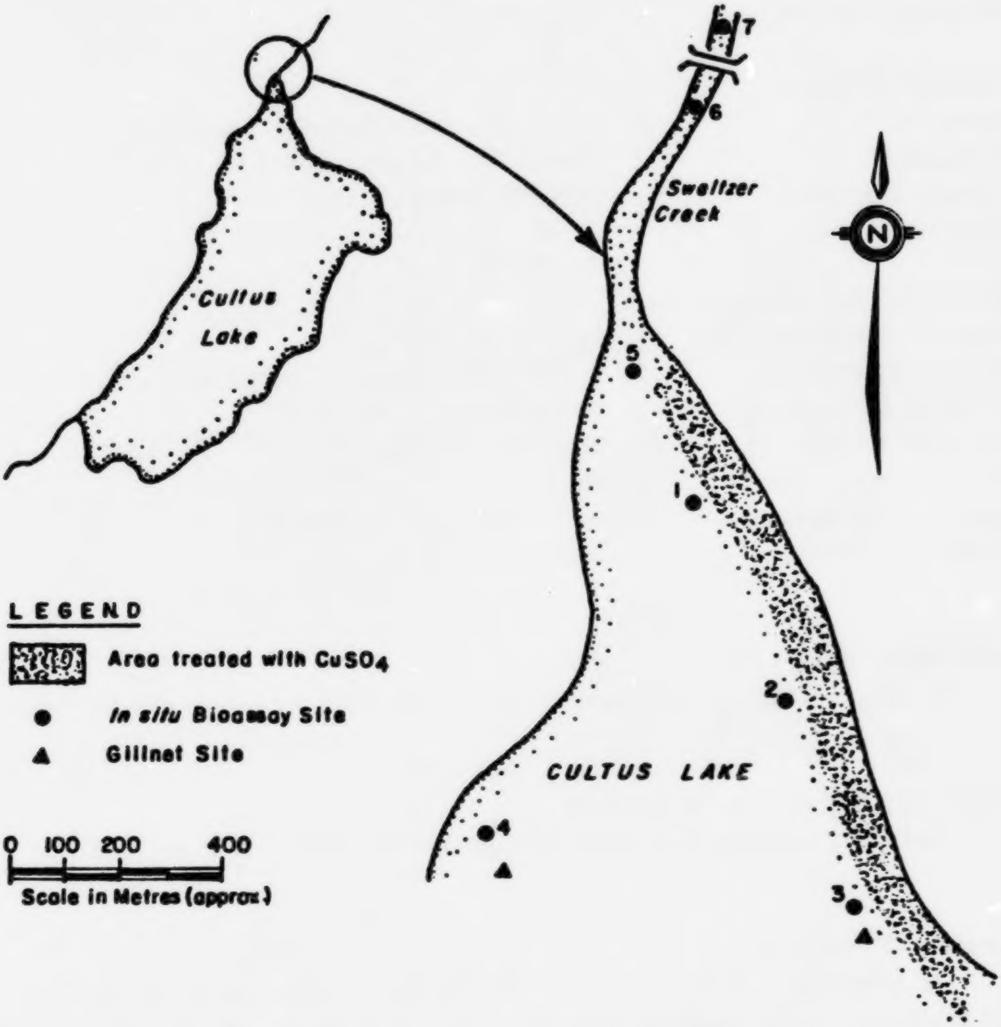

Cultus Lake
Sweltzer Creek
7
6
5
1
2
3
4
CULTUS LAKE
N
LEGEND
▨ Area treated with CuSO4
● *In situ* Bioassay Site
▲ Gillnet Site
0 100 200 400
Scale in Metres (approx.)

FIGURE 6-6 *IN SITU* FISH BIOASSAY AND GILLNET SITES IN CULTUS LAKE (1978)

Monitoring Study No. : 24
Monitoring Agency : Aquatic Studies Branch of the British Columbia Ministry of Environment
Proponent of Project : As above

PROJECT DETAILS

Location : Wood Lake and Kalamalka Lake, B.C.
Purpose : Control of Aquatic Weeds
Target species : Eurasian Water Milfoil
Treatment area : 20 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Aqua-Kleen 20
Active Ingredient : 2,4-D butoxy ethanol ester and acid
Rate of Application : 45 kg/ha
Carrier/diluent : Attaclay granules
Drift Control Agent : NA
Application Method : Motorized spin spreader
Treatment Date : September, 1980

MONITORING OBJECTIVE

1. To monitor the persistence of 2,4-D residues in water and sediment.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 6-7, 6-8, 6-9, 6-10 and Tables 6-1 and 6-2.

SUMMARY OF RESULTS

In Wood Lake, 2,4-D residues persisted in water up to 50 days, while in Kalamalka Lake the chemical was detected in water up to 32 days following an application of 4.5 kg/ha of Aqua-Kleen 20.

REFERENCE:

Rudolph, J.R. and C.E.W. Dyer (1981). Control of *Myriophylhum spicatum* in Kalamalka and Wood Lakes Using 2,4-D butoxyethanol ester in 1980. Vol. 1. Data Report, File No. 0316533. British Columbia Ministry of Environment.

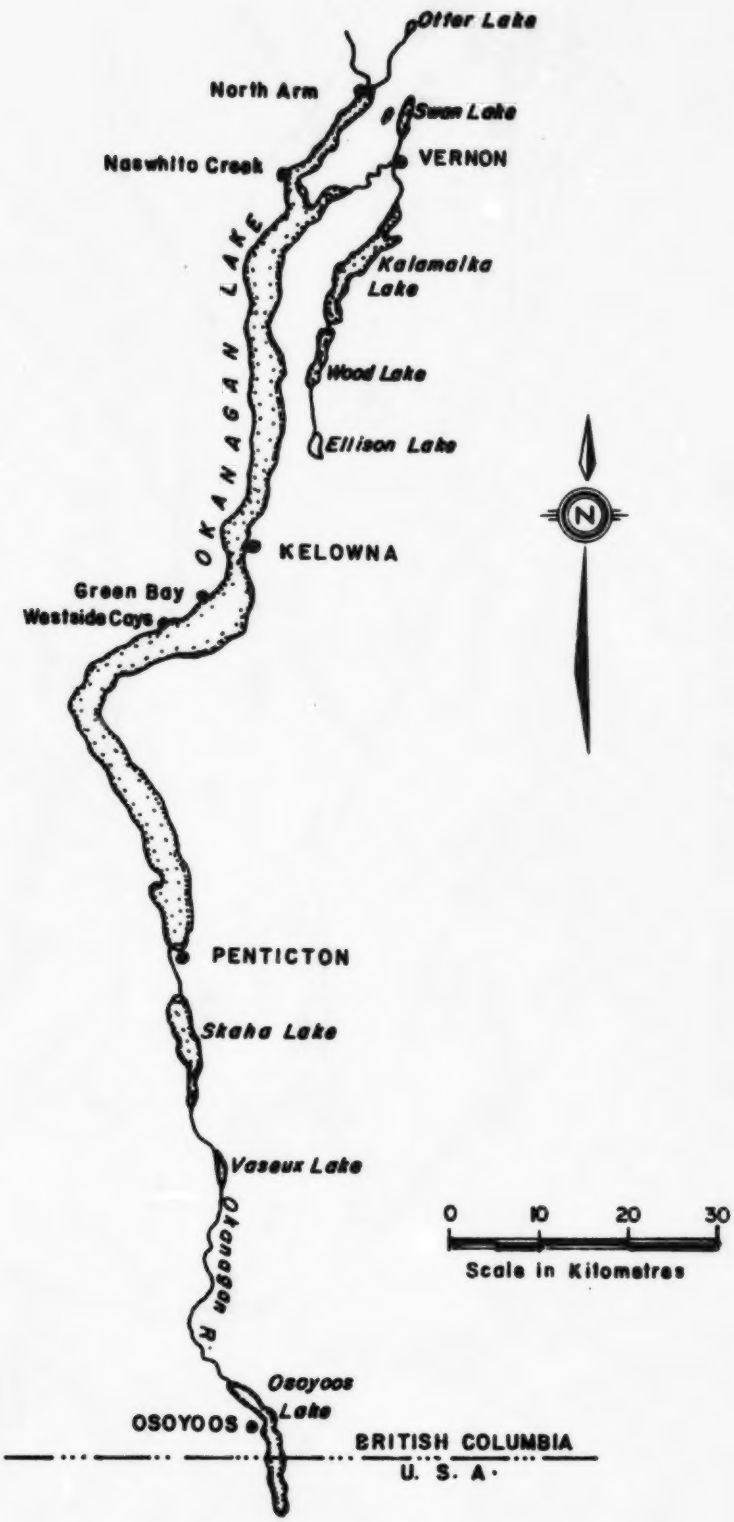
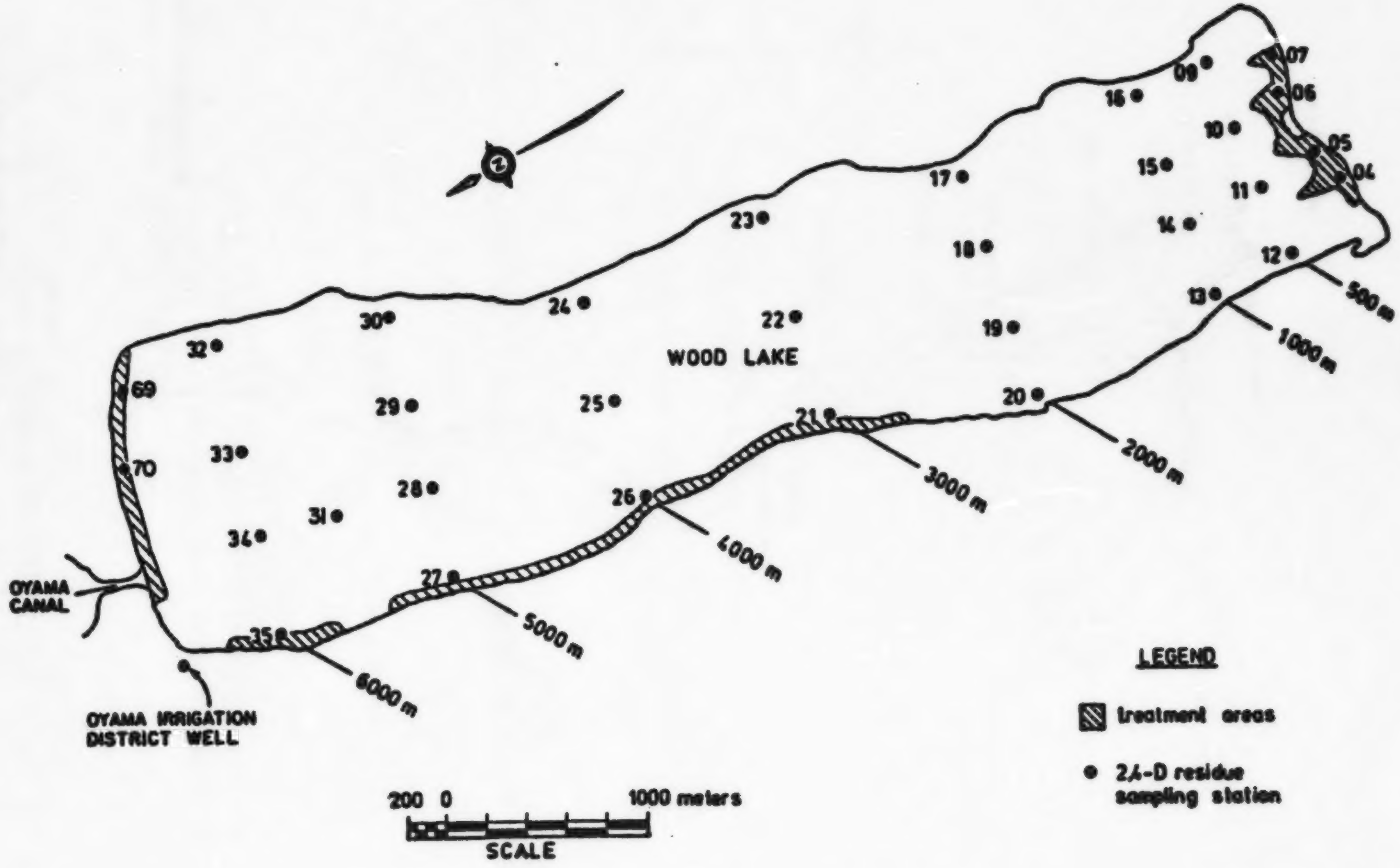

Otter Lake
North Arm
Swan Lake
VERNON
Naswhito Creek
OKANAGAN LAKE
Kalamalka Lake
Wood Lake
Ellison Lake
N
KELOWNA
Green Bay
Westside Cays
PENTICTON
Skaha Lake
Vaseux Lake
Okanagan R.
0
10
20
30
Scale in Kilometres
Osoyoos Lake
OSOYOOS
BRITISH COLUMBIA
U. S. A.

FIGURE 6-7 THE OKANAGAN VALLEY LAKES SYSTEM

FIGURE 6-8 WOOD LAKE SAMPLING STATIONS, 1980


WOOD LAKE
04
05
06
07
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
69
70
500 m
1000 m
2000 m
3000 m
4000 m
5000 m
6000 m
OYAMA CANAL
OYAMA IRRIGATION DISTRICT WELL
200 0 1000 meters
SCALE
LEGEND
treatment areas
2,4-D residue sampling station

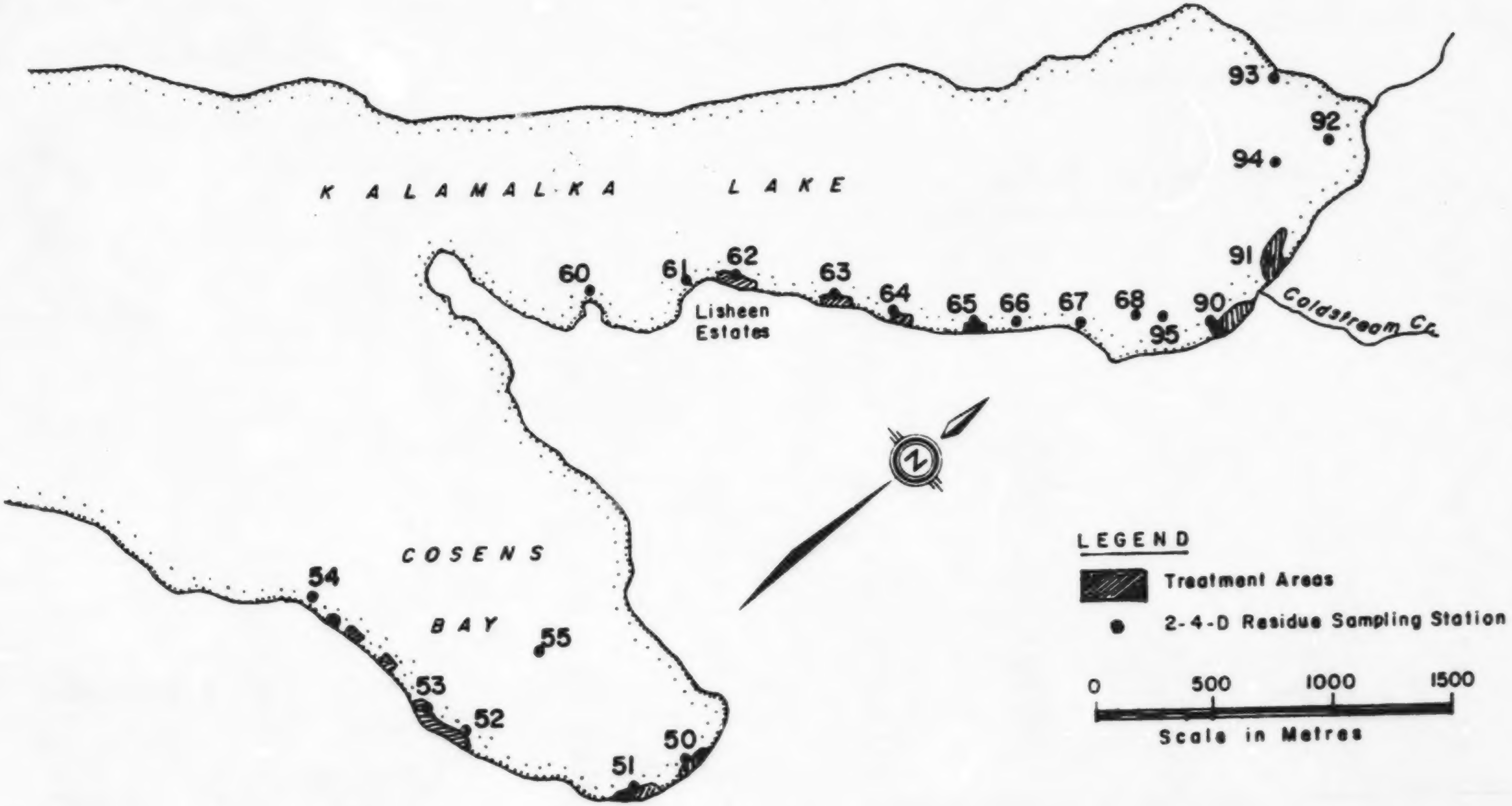

K A L A M A L K A   L A K E
C O S E N S
B A Y
Lisheen Estates
Coldstream Cr.
93
92
94
91
90
95
68
67
66
65
64
63
62
61
60
54
55
53
52
51
50
N
LEGEND
▨ Treatment Areas
● 2-4-D Residue Sampling Station
0
500
1000
1500
Scale in Metres

FIGURE 6-9 KALAMALKA LAKE (North End) - SAMPLING STATIONS, 1980

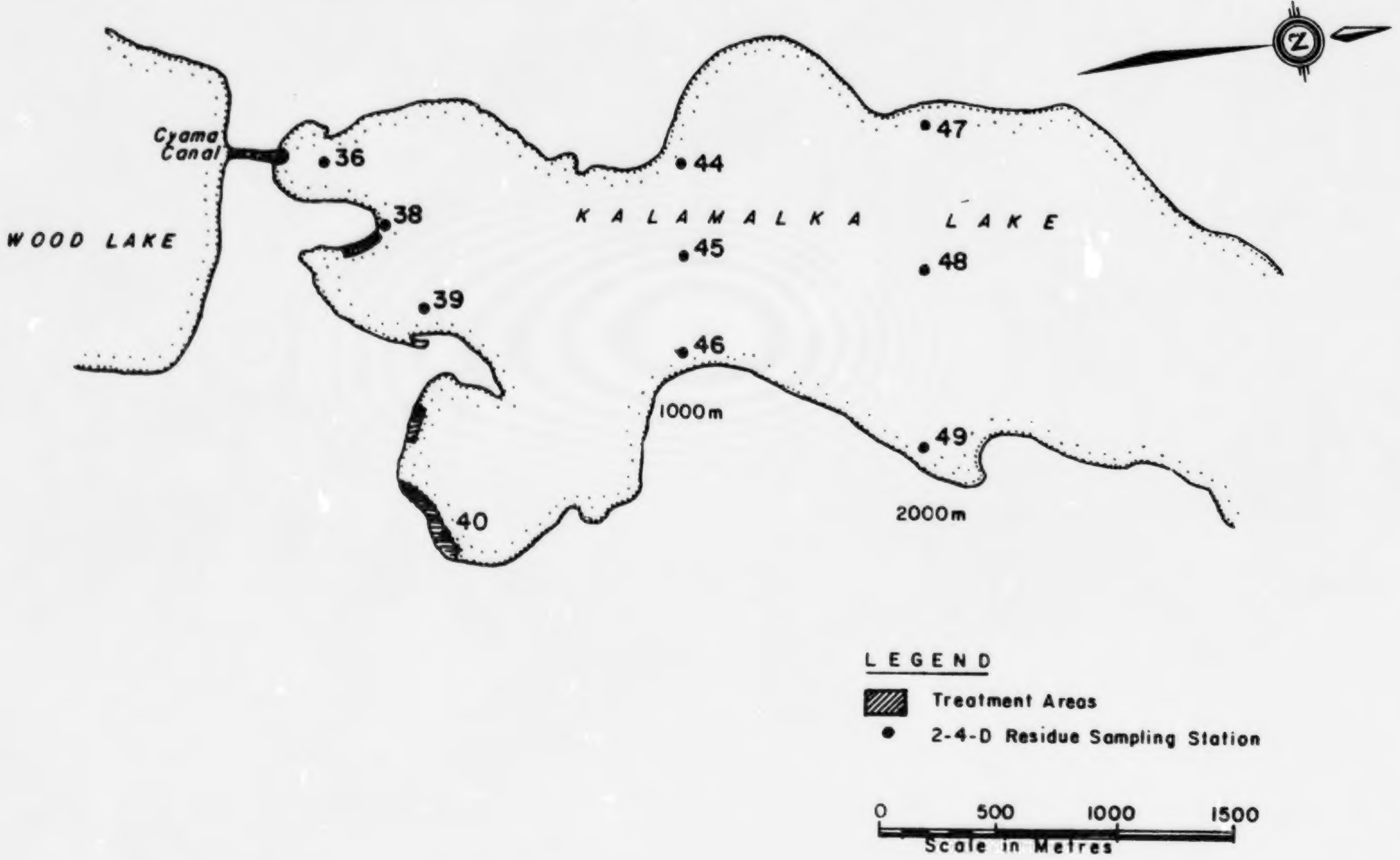

WOOD LAKE
Cyama Canal
36
38
39
40
44
45
46
47
48
49
KALAMALKA LAKE
1000m
2000m
Z
LEGEND
▨ Treatment Areas
● 2-4-D Residue Sampling Station
0
500
1000
1500
Scale in Metres

FIGURE 6-10 KALAMALKA LAKE (South End) - SAMPLING STATIONS, 1980

TABLE 6-1 CONCENTRATIONS OF 2,4-D (mg/L) IN WATER SAMPLED FROM WOOD - LAKE SOUTH END TREATMENT; TREATED SEPTEMBER 10, 1980

INSITE RESIDUES

STATION[1]	DEPTH (m)	ANALYSIS	HOUR 1 SEPT. 10	HOUR 3 SEPT. 10	HOUR 5 SEPT. 10	DAY 1 SEPT. 11	DAY 4 SEPT. 14	DAY 5 SEPT. 15	DAY 7 SEPT. 17	DAY 11 SEPT. 21
1122304	Top (0.1)	BEE	.403	.41	.36	.019	.004	**	ND	**
	Bottom (1.5)	BEE	.75	.37	.11	.047	.017	**	ND	**
	Top	ACID	.21	.42	.33	.43	.019	.011	.017	**
	Bottom	ACID	.38	.47	.42	.62	.001	.016	.017	**
	Top	DCP	ND	.006	.004	ND	ND	**	**	**
	Bottom	DCP	.005	.004	ND	ND	ND	**	**	**
1122305	Top (0.1)	BEE	.002	.226	.21	.0038	.003	**	ND	**
	Bottom (2.0)	BEE	.024	.16	.72	.006	.011	**	ND	**
	Top	ACID	.0063	.18	.60	.039	.016	.0067	.026	**
	Bottom	ACID	.07	.30	.092	.03	.005	.0203	.015	**
	Top	DCP	.007	.003	.014	ND	ND	**	**	**
	Bottom	DCP	.001	.006	.008	ND	ND	**	**	**
1122306	Top (0.1)	BEE	.032	.15	**	.021	.004	**	ND	**
	Bottom (3.0)	BEE	.072	.013	**	.008	ND	**	ND	**
	Top	ACID	.033	.032	**	.023	.022	.0011	.0037	**
	Bottom	ACID	.026	.11	**	.032	.018	.016	ND	**
	Top	DCP	ND	ND	**	ND	ND	**	**	**
	Bottom	DCP	ND	.006	**	ND	ND	**	**	**
1122307	Top (0.1)	BEE	.088	.12	**	.006	ND	**	ND	**
	Bottom (2.0)	BEE	.05	1.38	**	.003	ND	**	ND	**
	Top	ACID	.048	.018	**	.029	.0035	.0034	.0096	**
	Bottom	ACID	.038	.49	**	.079	.0059	.027	.014	**
	Top	DCP	.001	ND	**	ND	ND	**	**	**
	Bottom	DCP	ND	.009	**	ND	ND	**	**	**

** - Not Sampled

[1] Last two numbers refer to station numbers on Figure 2

Note: Pretreatment samples taken from just above the bottom of stations 1122304 - 112307 on September 9, 1980 showed non-detectable levels of 2,4-D Acid, BEE, or DCP

TABLE 6-1 CONCENTRATIONS OF 2,4-D (mg/L) IN WATER SAMPLED FROM WOOD - LAKE SOUTH END TREATMENT; TREATED SEPTEMBER 10, 1980
(Continued)

INSITE RESIDUES

STATION[1]	DEPTH (m)	ANALYSIS	DAY 12 SEPT. 22	DAY 22 OCT. 02	DAY 29 OCT. 09	DAY 36 OCT. 16	DAY 40 OCT. 20	DAY 43 OCT. 23	DAY 47 OCT. 27	DAY 50 OCT. 30	DAY 55 NOV. 4	DAY 58 NOV. 7
1122304	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**	**
	Bottom (1.5)	BEE	**	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	.0053	.0051	.0066	.0081	.0061	.0049	.0021	ND	ND
	Bottom	ACID	.0048	.022	.0081	.0056	**	**	**	**	**	**
	Top	DCP	**	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**	**
1122305	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**	**
	Bottom (2.0)	BEE	**	**	**	**	**	**	**	**	**	**
	Top	ACID	.0037	.0075	.0055	.0077	.013	.012	.0065	.0023	ND	ND
	Bottom	ACID	.0029	.008	.0046	.0058	**	**	**	**	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**	**
1122306	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**	**	**
	Top	ACID	.003	.0049	.0061	.007	.0037	.0088	.003	ND	ND	ND
	Bottom	ACID	.0029	.0046	.0056	.009	**	**	**	**	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**	**
1122307	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**	**
	Bottom (2.0)	BEE	**	**	**	**	**	**	**	**	**	**
	Top	ACID	.006	.0067	.0041	.0042	.0051	.0069	.0043	.0013	ND	ND
	Bottom	ACID	.0046	.0043	.0044	.0065	**	**	**	**	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**	**

** - Not Sampled

[1] Last two numbers refer to station numbers on Figure 2

TABLE 6-2 CONCENTRATIONS OF 2,4-D (mg/L) IN WATER SAMPLED FROM KALAMALKA LAKE - COSENS BAY TREATMENT; TREATED JUNE 26, 198

STATION[1]	DEPTH (m)	ANALYSIS	DAY 0 JUNE 26	DAY 1 JUNE 27	DAY 4 JUNE 30	DAY 6 JULY 2	DAY 7 JULY 3	DAY 10 JULY 6	DAY 11 JULY 7	DAY 12 JULY 8
1122350	Top (0.1)	BEE	ND	*	*	ND	ND	ND	ND	**
	Bottom (3.0)	BEE	.026	.0048	ND	ND	ND	.0011	ND	**
	Top	ACID	.0011	*	*	ND	ND	ND	.0016	.0012
	Bottom	ACID	.0066	.010	.0024	.0034	ND	ND	.0011	.0024
	Top	DCP	ND	*	*	*	ND	ND	**	**
	Bottom	DCP	ND	ND	ND	ND	ND	ND	**	**
1122351	Top (0.1)	BEE	ND	ND	*	ND	ND	ND	ND	**
	Bottom (3.0)	BEE	.0155	ND	ND	ND	ND	ND	ND	**
	Top	ACID	.0037	.0085	*	ND	ND	ND	.0015	.0011
	Bottom	ACID	.0057	.0064	.0074	.0022	ND	.0011	.0062	.0013
	Top	DCP	ND	ND	ND	*	ND	ND	**	**
	Bottom	DCP	ND	ND	ND	ND	ND	ND	**	**
1122352	Top (0.1)	BEE	.0036	ND	ND	ND	ND	ND	ND	**
	Bottom (3.0)	BEE	.0210	*	*	ND	ND	*	ND	**
	Top	ACID	.0096	.0016	.0017	ND	.0011	ND	.0012	.0012
	Bottom	ACID	.0210	*	*	*	.0028	.00132	.0012	.0145
	Top	DCP	ND	ND	ND	ND	ND	ND	**	**
	Bottom	DCP	ND	*	*	ND	ND	*	**	**
1122353	Top (0.1)	BEE	ND	ND	ND	ND	ND	ND	ND	**
	Bottom (0.75)	BEE	.0084	.0050	.0013	ND	ND	ND	ND	**
	Top	ACID	.0017	.0027	.0018	ND	ND	ND	.0022	ND
	Bottom	ACID	.0150	.0061	.0230	.0028	.0012	.0038	.0033	.0016
	Top	DCP	ND	ND	ND	ND	ND	ND	**	**
	Bottom	DCP	ND	ND	ND	ND	ND	ND	**	**
1122354	Top (0.1)	BEE	ND	ND	ND	ND	ND	ND	ND	**
	Bottom (0.75)	BEE	ND	ND	ND	ND	ND	ND	ND	**
	Top	ACID	ND	ND	ND	ND	ND	.0010	.0020	.0018
	Bottom	ACID	ND	ND	.0018	ND	ND	.0038	.0038	.0015
	Top	DCP	ND	ND	ND	ND	ND	ND	**	**
	Bottom	DCP	ND	ND	ND	ND	ND	ND	**	**
1122355	Top (0.1)	BEE	ND	**	*	ND	ND	ND	ND	**
	Bottom	BEE	**	**	**	**	**	**	**	**
	Top	ACID	ND	**	*	ND	ND	.0011	.0012	ND
	Bottom	ACID	**	**	**	**	**	**	**	**
	Top	DCP	ND	**	*	ND	ND	ND	ND	**
	Bottom	DCP	**	**	**	**	**	**	**	**

* - Broken

** - Not Sampled

[1] Last two numbers refer to station numbers on Figure 2

Note: Pretreatment sampling was carried out at stations 1122350, 1122351 and 1122352 on June 18, 1980; station 1122354 on June, 24, 1980 and at station 1122353 on June 25, 1980. All sampling was from just above the bottom; and all results showed non-detectable amounts of 2,4-D.

TABLE 6-2 CONCENTRATIONS OF 2,4-D (mg/L) IN WATER SAMPLED FROM KALAMALKA LAKE - COSENS BAY TREATMENT; TREATED JUNE 26, 1980

(Continued)

STATION[1]	DEPTH (m)	ANALYSIS	DAY 13 JUNE 9	DAY 14 JULY 10	DAY 17 JULY 13	DAY 18 JULY 14	DAY 19 JULY 15	DAY 20 JULY 16	DAY 21 JULY 17	DAY 24 JULY 20
1122350	Top (0.1)	BEE	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**
	Top	ACID	ND	.0017	.0160	ND	.0012	ND	.0013	ND
	Bottom	ACID	ND	.0021	.0012	.0014	.0011	ND	.0014	.0011
	Top	DCP	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**
1122351	Top (0.1)	BEE	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**
	Top	ACID	ND	.0018	ND	**	.0011	.0012	.0017	ND
	Bottom	ACID	.0017	.0054	.0018	.0047	.0011	.0021	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**
1122352	Top (0.1)	BEE	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**
	Top	ACID	.0014	ND	ND	.0016	.0011	.0010	ND	ND
	Bottom	ACID	.0016	*	.0054	ND	.0014	**	.0011	.0025
	Top	DCP	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**
1122353	Top (0.1)	BEE	**	**	**	**	**	**	**	**
	Bottom (0.75)	BEE	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	.0033	.0019	*	.0012	ND	ND
	Bottom	ACID	.0047	ND	.0034	.0013	ND	.0016	.0020	.0027
	Top	DCP	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**
1122354	Top (0.1)	BEE	**	**	**	**	**	**	**	**
	Bottom (0.75)	BEE	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	.0021	ND	ND	.0017	ND	ND
	Bottom	ACID	ND	ND	ND	.0013	ND	ND	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**
1122355	Top (0.1)	BEE	**	**	**	**	**	**	**	**
	Bottom	BEE	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	.0013	.0010	ND	ND	ND	ND
	Bottom	ACID	**	**	**	**	**	**	**	**
	Top	DCP	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**

* - Broken

** - Not Sampled

[1] Last two numbers refer to station numbers on Figure 2

Note: Pretreatment sampling was carried out at stations 1122350, 1122351 and 1122352 on June 18, 1980; station 1122354 on June, 24, 1980 and at station 1122353 on June 25, 1980. All sampling was from just above the bottom; and all results showed non-detectable amounts of 2,4-D.

TABLE 6-2 CONCENTRATIONS OF 2,4-D (mg/L) IN WATER SAMPLED FROM KALAMALKA LAKE - COSENS BAY TREATMENT; TREATED JUNE 26, 1980

(Continued)

STATION[1]	DEPTH (m)	ANALYSIS	DAY 25 JULY 21	DAY 26 JULY 22	DAY 27 JULY 23	DAY 28 JULY 24	DAY 31 JULY 27	DAY 32 JULY 28	DAY 33 JULY 29	DAY 34 JULY 30	DAY 35 JULY 31
1122350	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	ND	ND	.0017	ND	ND	ND	ND
	Bottom	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**
1122351	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Bottom	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**
1122352	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**
	Bottom (3.0)	BEE	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Bottom	ACID	ND	.0011	ND	ND	ND	.0010	ND	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**
1122353	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**
	Bottom (0.75)	BEE	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Bottom	ACID	.0010	ND	ND	ND	.0021	ND	ND	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**
1122354	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**
	Bottom (0.75)	BEE	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Bottom	ACID	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Top	DCP	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**
1122355	Top (0.1)	BEE	**	**	**	**	**	**	**	**	**
	Bottom	BEE	**	**	**	**	**	**	**	**	**
	Top	ACID	ND	ND	ND	ND	ND	**	**	**	**
	Bottom	ACID	**	**	**	**	**	**	**	**	**
	Top	DCP	**	**	**	**	**	**	**	**	**
	Bottom	DCP	**	**	**	**	**	**	**	**	**

** - Not Sampled

[1] Last two numbers refer to station numbers on Figure 3

Monitoring Study No.	25
Monitoring Agency	The National Water Research Institute, Inland Waters Directorate
Proponent of Project	Aquatic studies Branch of the British Columbia Ministry of Environment

PROJECT DETAILS

Location	Wood Lake and Kalamalka Lake
Purpose	Control of Aquatic Weeds
Target species	Eurasian Water Milfoil
Treatment area	10 ha

PESTICIDE USE INFORMATION

Name of Pesticide	Aqua-Kleen 20
Active Ingredient	2,4-D butoxy ethanol ester
Rate of Application	22 - 45 kg/ha
Carrier/diluent	Attaclay granules
Drift Control Agent	NA
Application Method	Motorized spin spreader
Treatment Date	June, 1979

MONITORING OBJECTIVE

1. To monitor the persistence of 2,4-D residues in the sediment of Wood and Kalamalka Lake

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 6-11, 6-12 and Tables 6-3 and 6-4.

SUMMARY OF RESULTS

Residues of 2,4-D butoxy ethanol ester (2,4-D BEE) and two of its breakdown products, 2,4-D dichloro- phenoxyacetic acid (2,4-D, and 2,4-dichlorophenol [2,4-D]) persisted in the sediments of Wood and Kalamalka Lake for periods varying from 54 to 182 days. In both lakes, 2,4-D was the most persistent of the three forms; non-detectable levels were respectively reached in 120 days and 180 days after treatment in Wood and Kalamalka Lake. 2,4-D BEE and 2,4-D dropped below detection after 54-77 days, except in Kalamalka Lake where the ester persisted longer, about 72-125 days. Very low concentrations of herbicides in the microlayer in both Wood and Kalamalka Lakes were found to spread over large untreated areas within 24 hours of application.

CONCLUSION

Data from this investigation confirmed previous studies that 2,4-D, a polar herbicide, does not appear to persist or accumulate beyond the season of application.

REFERENCE:

Bothwell, M.L. and R.J. Daley (1981). Selected Observations on the Persistence and Transport of Residues from Aqua Kleen 20 (2,4-D) Treatments in Wood and Kalamalka Lakes, B.C. Inland Waters Directorate, Pacific and Yukon Region, Vancouver, B.C.

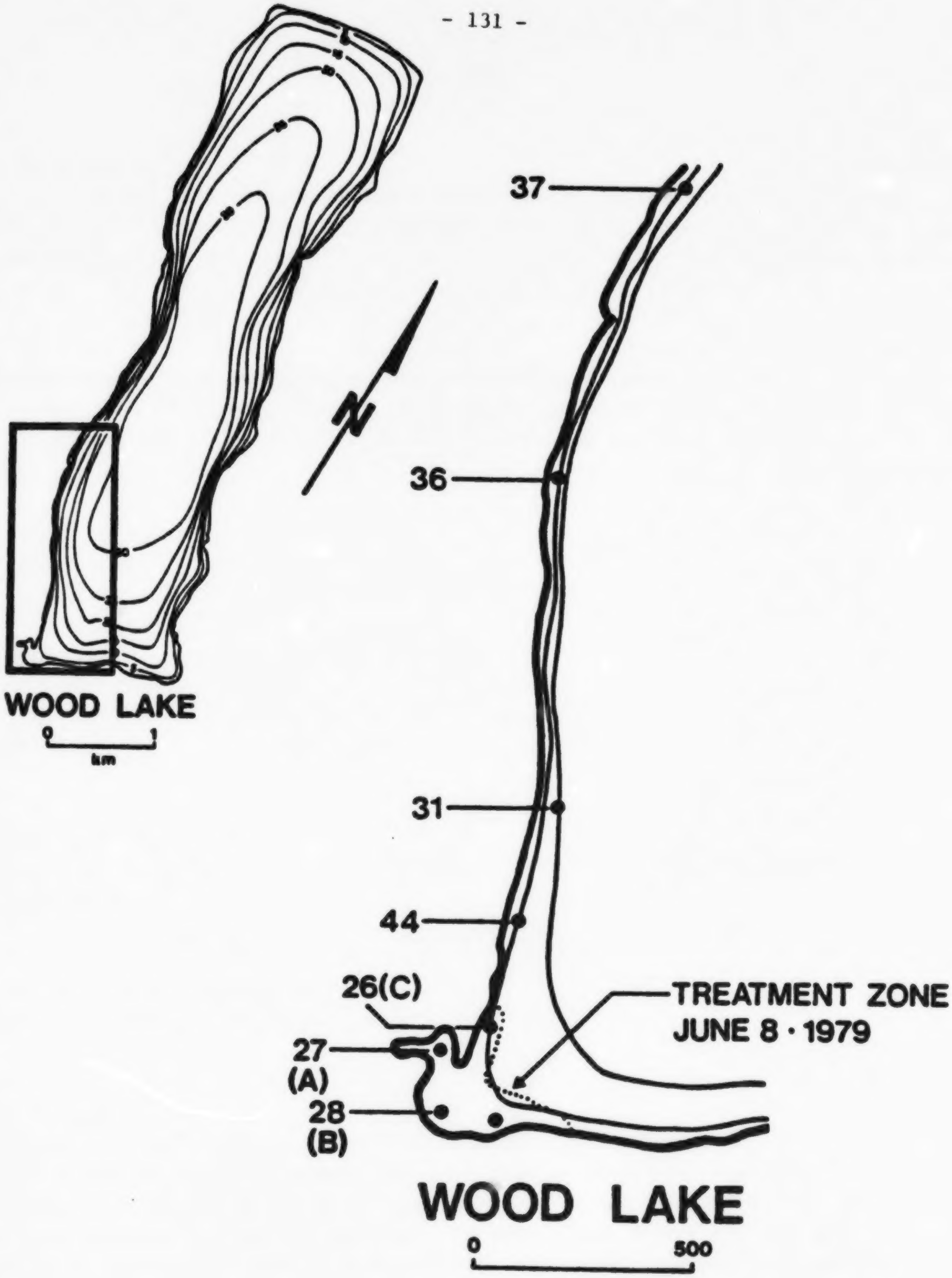

WOOD LAKE
0
1
km
N
37
36
31
44
26(C)
27
(A)
28
(B)
TREATMENT ZONE
JUNE 8 · 1979
WOOD LAKE
0
500
metres

Figure 6-11 Location of stations for microlayer and core sampling of Wood Lake, 1979. Numbered stations were used for microlayer sampling. Lettered stations were coring sites.

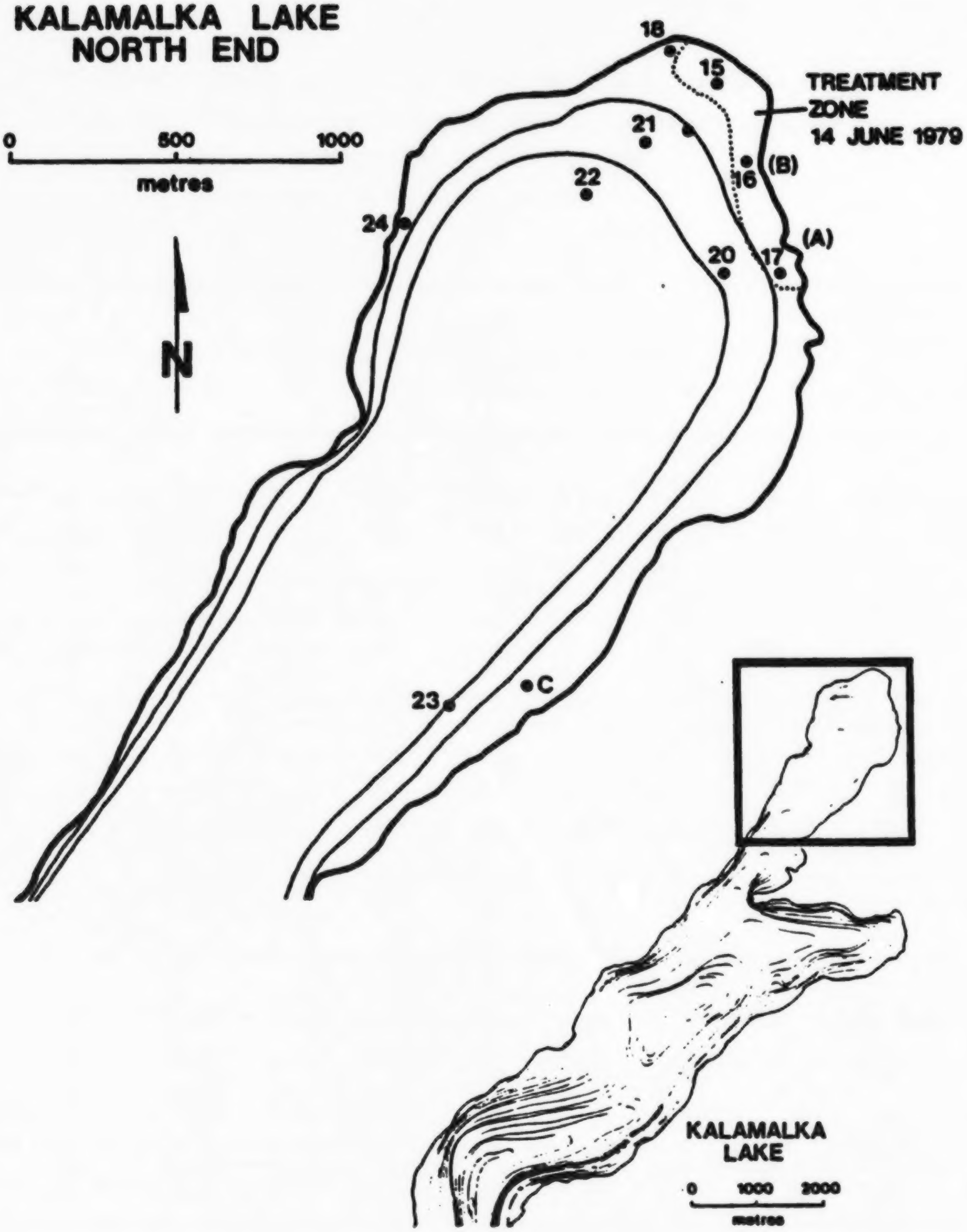

KALAMALKA LAKE
NORTH END
0
500
1000
metres
N
18
15
TREATMENT
ZONE
14 JUNE 1979
21
(B)
16
22
24
(A)
20
17
23
C
KALAMALKA
LAKE
0
1000
2000
metres

Figure 6-12 Location of stations for microlayer and core sampling of Kalamalka Lake, 1979. Numbered stations were used for microlayer sampling. Lettered stations were coring sites.

TABLE 6-3 2,4-D RESIDUES IN WOOD LAKE SEDIMENT (0-2 cm depth) FOLLOWING AQUA-KLEEN 20 TREATMENT ON 8 JUNE 1979 ($ug.g^{-1}$ dry wt.).
See Figure 6-11 for station location.

COMPOUND	STATION	DAYS (post treatment)							
		1	11	19	27	41	54	77	120
2,4-D BEE	A	3.9	4.3	1.9	ND	ND	0.36	ND	ND
	B	120	3.9	2.0	37	ND	0.08	ND	ND
	C	29	63	9.1	26	0.48	ND	ND	ND
	Mean	51	24	4.3	21	0.16	0.15	ND	ND
2,4-D	A	25	4.5	0.41	0.052	0.023	0.036	ND	ND
	B	68	5.1	2.1	3.54	0.11	0.045	0.053	ND
	C	2.8	6.6	3.6	1.32	0.33	0.25	0.025	ND
	Mean	32	5.4	2.0	1.6	0.15	0.11	0.026	ND
2,4-DP	A	0.13	0.67	0.38	0.24	0.19	0.047	ND	ND
	B	0.26	0.95	1.3	0.23	0.15	0.057	ND	ND
	C	ND	0.24	0.39	0.069	0.024	0.023	ND	ND
	Mean	0.13	0.62	0.69	0.18	0.12	0.042	ND	ND

ND = Non-Detectable

TABLE 6-4 2,4-D RESIDUES IN KALAMALKA LAKE SEDIMENT (0-2 cm depth) FOLLOWING AQUA-KLEEN 20 TREATMENT ON 14 JUNE 1979 (ug.g^{-1} dry wt.).
See Figure 6-12 for station location.

COMPOUND	STATION	DAYS (post treatment)								
		1	7	15	22	32	53	72	125	182
2,4-D BEE	B	0.78	7.2	16	2.1	2.0	0.061	ND	ND	ND
	A	24	14	0.32	47	5.0	2.7	5.1	ND	ND
	Mean	12	11	8.2	25	3.5	1.4	2.8	ND	ND
	Control C	ND	ND	0.036	ND	-	-	-	-	-
2,4-D	B	1.6	16	1.6	2.7	1.7	0.17	0.24	ND	0.17
	A	16	3.4	0.2	5.7	2.2	1.3	0.12	0.015	ND
	Mean	8.8	9.7	0.9	4.2	2.0	0.79	0.18	0.008	0.009
	Control C	ND	ND	ND	0.011	-	-	-	-	-
2,4-DP	B	ND	0.031	ND	0.036	0.033	0.027	ND	ND	ND
	A	0.081	0.047	ND	0.028	0.046	0.068	ND	ND	ND
	Mean	0.041	0.039	ND	0.032	0.040	0.048	ND	ND	ND
	Control C	ND	ND	ND	ND	-	-	-	-	-

ND = Non-Detectable

Monitoring Study No. : 26
Monitoring Agency : Fish and Wildlife Branch of the British Columbia Ministry of Environment
Proponent of Project : Aquatic studies Branch of the British Columbia Ministry of Environment

PROJECT DETAILS
Location : North Arm and selected locations of Okanagan Lake
Purpose : Control of Aquatic Weeds
Target species : Eurasian Water Milfoil
Treatment area : 6 ha

PESTICIDE USE INFORMATION
Name of Pesticide : Aqua-Kleen 20
Active Ingredient : 2,4-D butoxy ethanol ester and acid
Rate of Application : 11 - 45 kg/ha
Carrier/diluent : Attaclay granules
Drift Control Agent : NA
Application Method : Motorized spin spreader
Treatment Date :

MONITORING OBJECTIVES

1. To monitor the direct and indirect detrimental effects of 2,4-D application on fish, water fowl, and Benthic invertebrates of the Okanagan Valley lakes system.
2. To monitor the persistence of 2,4-D residues in water sediments.

STUDY DESIGN, LAYOUT, & RESULTS

Refer to Figures 6-13, 6-14, 6-15 and Table 6-5.

SUMMARY OF RESULTS

In the small treatment areas monitored in this study, deleterious effects of 2,4-D BEE applications to fish and wildlife appeared to be minimal. However, the potential effects of large scale applications remain unknown.

CONCLUSIONS

1. Growth of green filamentous algae many have been stimulated in treated areas at Westside Cays and in the North Arm as a result of treatment, but no algal blooms involving toxic genera occurred.

CONCLUSIONS (cont.)

2. Herbicide was detected in an algal sample taken from Westside Cays.

3. A variety of non-target macrophyte species survived treatment in open water situations.

4. Non-target macrophytes collected approximately 3.5 months after treatment in the North Arm did not contain detectable levels of 2,4-D.

5. Toxic and/or secondary effects of herbicide application may have been responsible for the observed decrease of zooplankton diversity in the North Arm and at Westside Cays.

6. Benthic invertebrates in the North Arm treatment site experienced a short-term increase in abundance and a significant decrease in diversity as a result of treatment.

7. Fish mortality caused by the toxicity of BEE 2,4-D was not demonstrated in the field.

8. Accumulation of 2,4-D occurred in some fish, both dead and sacrificed. However, a number of fish exposed to 2,4-D did not contain detectable residues.

9. Waterfowl tissue taken from coots and grebes, the only species frequenting treated areas of the North Arm in significant numbers in 1977, did not contain 2,4-D.

10. In the small treatment areas monitored in this study, adverse environmental effects resulting from the use of BEE 2,4-D appear to have been inconsequential. However, the possible effects of large-scale applications on fish and waterfowl are still unknown.

REFERENCE

Robinson, M.C. and R.L. Morley (1980). A Monitoring Study of the Effects of 2,4-D on Fish and Waterfowl as applied in Lakes of the Okanagan Valley, 1977. Vol. ii. Inventory and Engineering Branch, File No. 0316533. British Columbia Ministry of Environment.

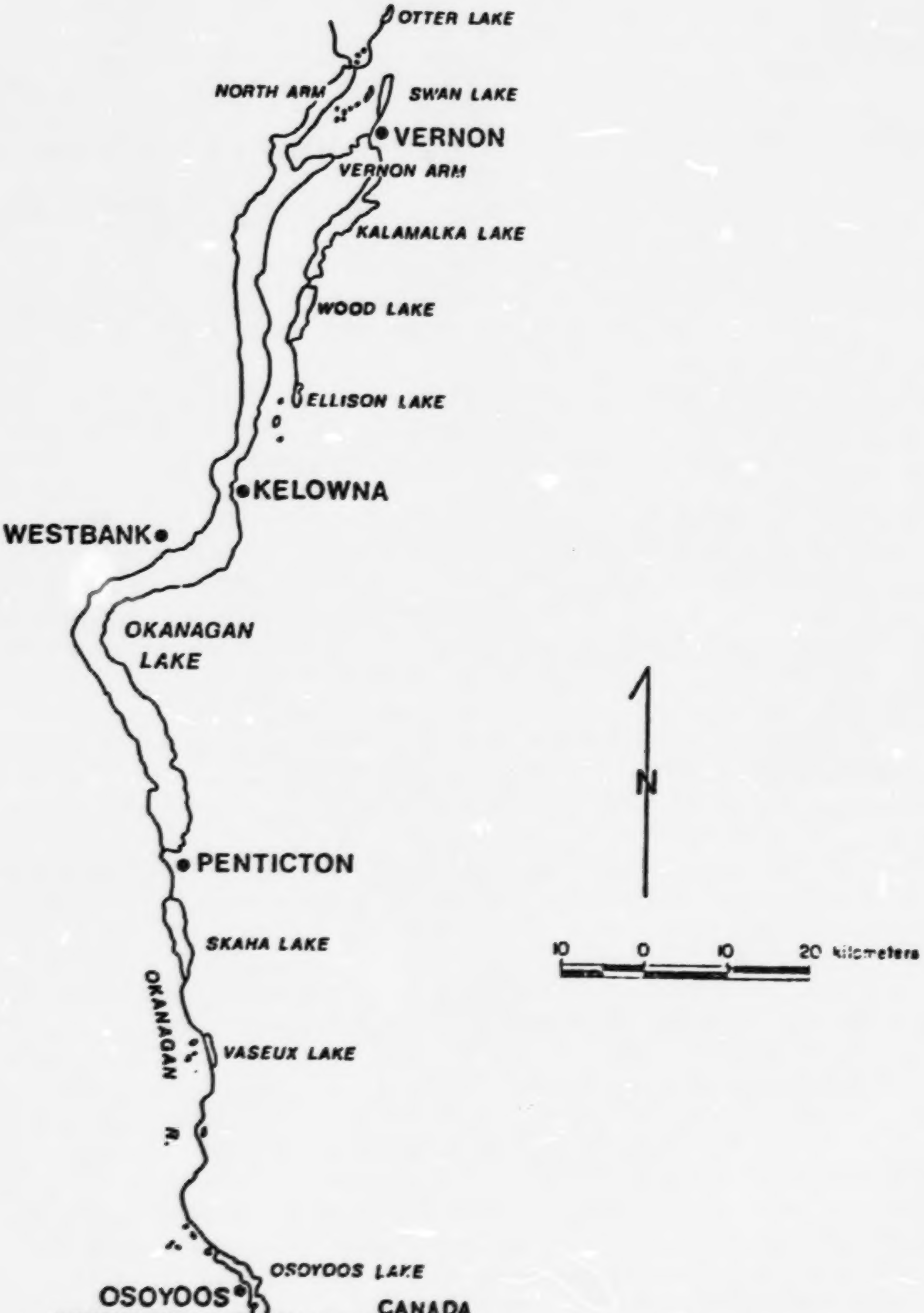

OTTER LAKE
NORTH ARM
SWAN LAKE
VERNON
VERNON ARM
KALAMALKA LAKE
WOOD LAKE
ELLISON LAKE
KELOWNA
WESTBANK
OKANAGAN LAKE
N
PENTICTON
SKAHA LAKE
OKANAGAN R.
VASEUX LAKE
OSOYOOS LAKE
OSOYOOS
CANADA
U.S.A
10 0 10 20 kilometers

FIGURE 6-13 THE OKANAGAN VALLEY LAKE SYSTEM

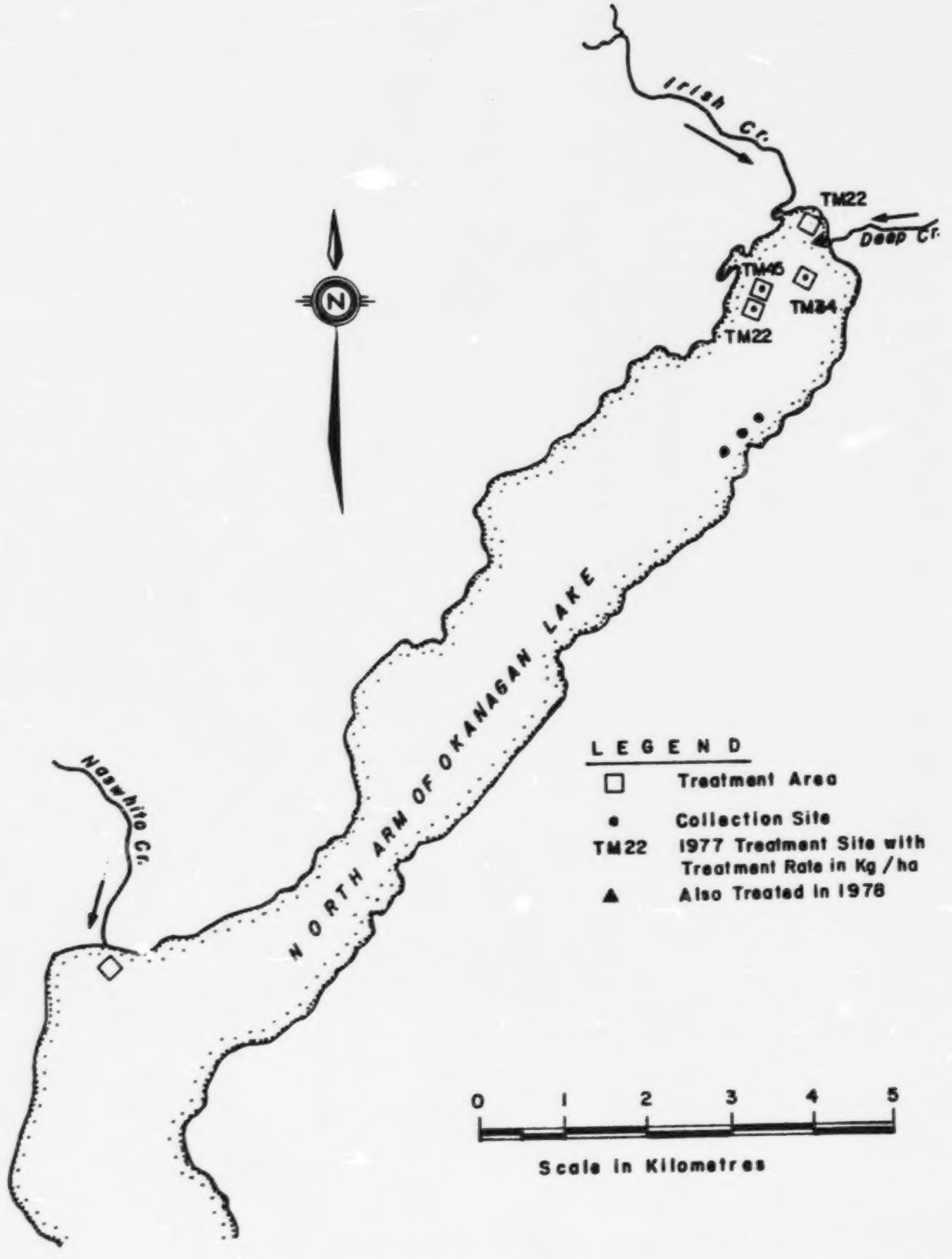

Irish Cr.
TM22
Deep Cr.
TM45
TM34
TM22
N
NORTH ARM OF OKANAGAN LAKE
Naswhito Cr.
LEGEND
□ Treatment Area
● Collection Site
TM22 1977 Treatment Site with Treatment Rate in Kg / ha
▲ Also Treated in 1978
0
1
2
3
4
5
Scale in Kilometres

FIGURE 6-14. COLLECTION SITES FOR INVERTEBRATES AND FISH

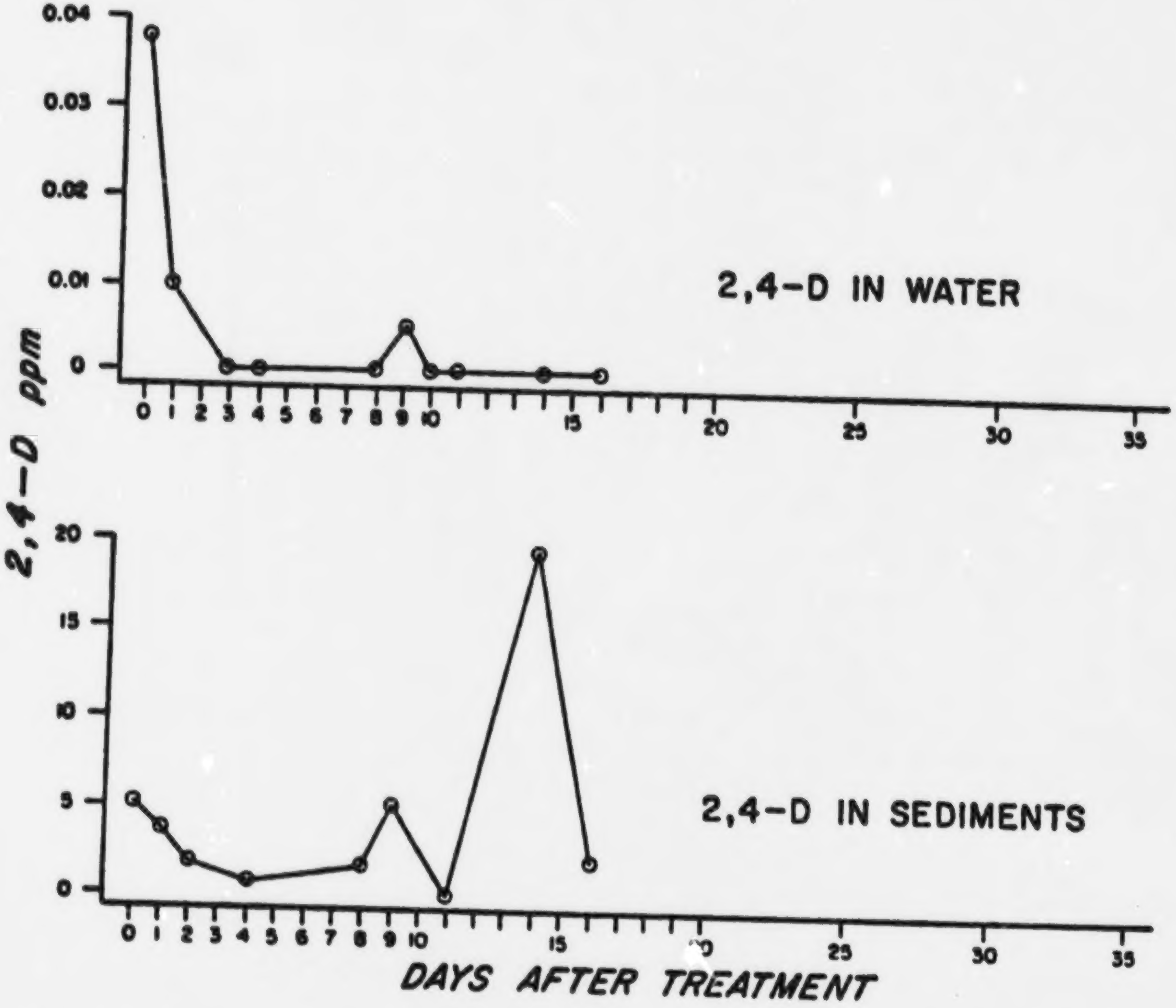


Figure 6-15 2,4-D Concentrations In Water and Sediment Samples from the Vicinity of Bioassay Cages in the North Arm of Okanagan Lake, 1977

TABLE 6-5 2,4-D Residue Levels in Water and Sediment

Sample Type	Days After Treatment	Location	2,4-D Level (ppm)
Water	0	TM 45	0.038
Water	1	TM 45	0.01
Water	3	TM 45	ND
Water	4	TM 45	ND
Water	8	TM 45	ND
Water	9	TM 45	0.006
Water	10	TM 45	ND
Water	11	TM 45	ND
Water	14	TM 45	ND
Water	16	TM 45	ND
Water	51	TM 45	ND
Water	51	TM 45	ND
Water	66	TM 34	ND
Water	66	TM 34	ND
Water	58	TM 45	ND
Water	58	TM 45	ND
Water	101	TM 45	ND
Water	101	TM 45	ND
Sediment	0	TM 45	5.39
Sediment	1	TM 45	3.98
Sediment	2	TM 45	1.94
Sediment	4	TM 45	0.97
Sediment	8	TM 45	1.67
Sediment	9	TM 45	5.30
Sediment	10	TM 45	2.77
Sediment	11	TM 45	ND
Sediment	14	TM 45	19.56
Sediment	16	TM 45	2.02
Sediment	51	TM 45	ND
Sediment	51	TM 45	ND
Sediment	58	TM 45	ND
Sediment	58	TM 45	3.57
Sediment	66	TM 34	ND
Sediment	66	TM 34	1.92
Sediment	101	TM 45	ND
Sediment	101	TM 45	5.26
Sediment	3	TM 45	ND
Sediment	9	TM 45	ND
Sediment	16	TM 45	ND
Sediment	23	TM 45	ND
Sediment	30	TM 45	ND
Sediment	30	CM 1	ND
Sediment	37	TM 45	ND
Sediment	44	TM 45	ND

APPENDIX VII

INDUSTRIAL/COMMERCIAL VEGETATION AND PEST CONTROL PROGRAMMES

Monitoring Study No. : 27
Monitoring Agency : Environmental Protection Service
Proponent of Project : B.C. Hydro & Power Authority

PROJECT DETAILS

Location : Surrey area (Ingledow Substation)
Purpose : Soil sterilization
Target species : Grasses, weeds
Treatment area : 25 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Spike
Active Ingredient : Tebuthiuron
Rate of Application : 4.5 kg/ha
Carrier/diluent : Water
Drift Control Agent : NA
Application Method : Powerhose and tractor mounted boom sprayer
Treatment Date : August 10, 1981

MONITORING OBJECTIVES

1. To determine whether spike leaches to the ditches surrounding the substation wire fence during the wet season
2. To investigate whether this herbicide reaches an unnamed tributary creek of the fishery sensitive Bear Creek.

STUDY DESIGN, LAYOUT, AND RESULTS

Refer to Figure 7-1.

SUMMARY AND RESULTS

Tebuthiuron residues were not detected from the water that leached out of the Hydro Substation at sampling sites A and B. A minor fish kill (of 15-20 juvenile salmonids - Coho spp) occurred in a ditch measuring 1 x 5m at sampling point B. Analysis of water samples and fish tissues showed that the fish kill was not related to the herbicide treatment.

REFERENCE

Wan, M.T. (1981). Environmental Protection Service memorandum Report. (October, 1981).

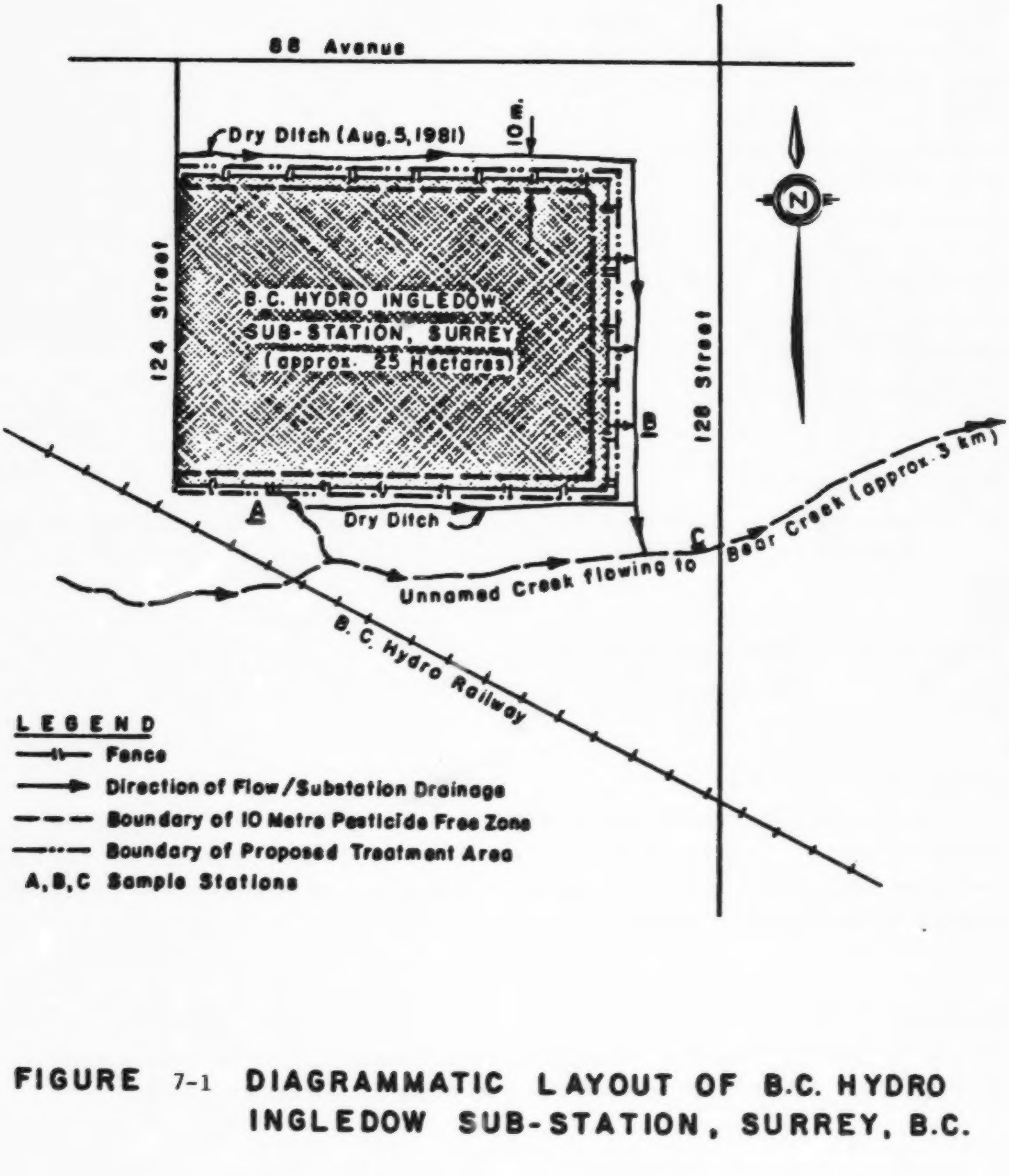

88 Avenue
124 Street
128 Street
Dry Ditch (Aug. 5, 1981)
10 m.
N
B.C. HYDRO INGLEDOW SUB-STATION, SURREY (approx. 25 Hectares)
B
A
C
Dry Ditch
Unnamed Creek flowing to Bear Creek (approx. 3 km)
B. C. Hydro Railway
LEGEND
Fence
Direction of Flow/Substation Drainage
Boundary of 10 Metre Pesticide Free Zone
Boundary of Proposed Treatment Area
A, B, C Sample Stations

FIGURE 7-1 DIAGRAMMATIC LAYOUT OF B.C. HYDRO INGLEDOW SUB-STATION, SURREY, B.C.

Monitoring Study No. : 28
Monitoring Agency : Environmental Protection Service & Transport Canada
Proponent of Project : Transport Canada and Dow Chemical of Canada

PROJECT DETAILS

Location : Vancouver International Airport
Purpose : Control of Cranefly
Target species : As above
Treatment area : 12 ha

PESTICIDE USE INFORMATION

Name of Pesticide : Dursban
Active Ingredient : Chlorpyrifos
Rate of Application : 0.5-1.5 kg/ha
Carrier/diluent : Attaclay granules/water
Drift Control Agent : NA
Application Method : Cyclone spreader, boom sprayer
Treatment Date :

MONITORING OBJECTIVE

1. To determine the effectiveness of a 10 meter pesticide free zone for the protection of ditch water from chloropyrifos leaching and runoff.

STUDY DESIGN, LAYOUT, AND RESULTS

Refer to Figures 7-2, 7-3 and Table 7-1.

SUMMARY AND RESULTS

Dursban residues were not detected in runoff water, nor in ditches. The negative results in soil samples taken from the 10 meter pesticide free zone indicated that there was no movement or transport of residues via runoff from treated areas to the adjacent ditches.

REFERENCE

Wan, M.T. (1982). Residue of Dursban at Vancouver International Airport. Environmental Protection Service Program Report. November, 1982.

TABLE 7-1 DURSBAN RESIDUES (10 days post spraying) AT VARIOUS SAMPLING POINTS AT VANCOUVER INTERNATIONAL AIRPORT

SAMPLING POINTS (See Figure 7-3)	DURSBAN (ppm)
Water (ditch)	0.001
Water (runoff)	0.001
Soil (10 meter pesticide free zone)	0.020
Soil (treated plots)	0.110

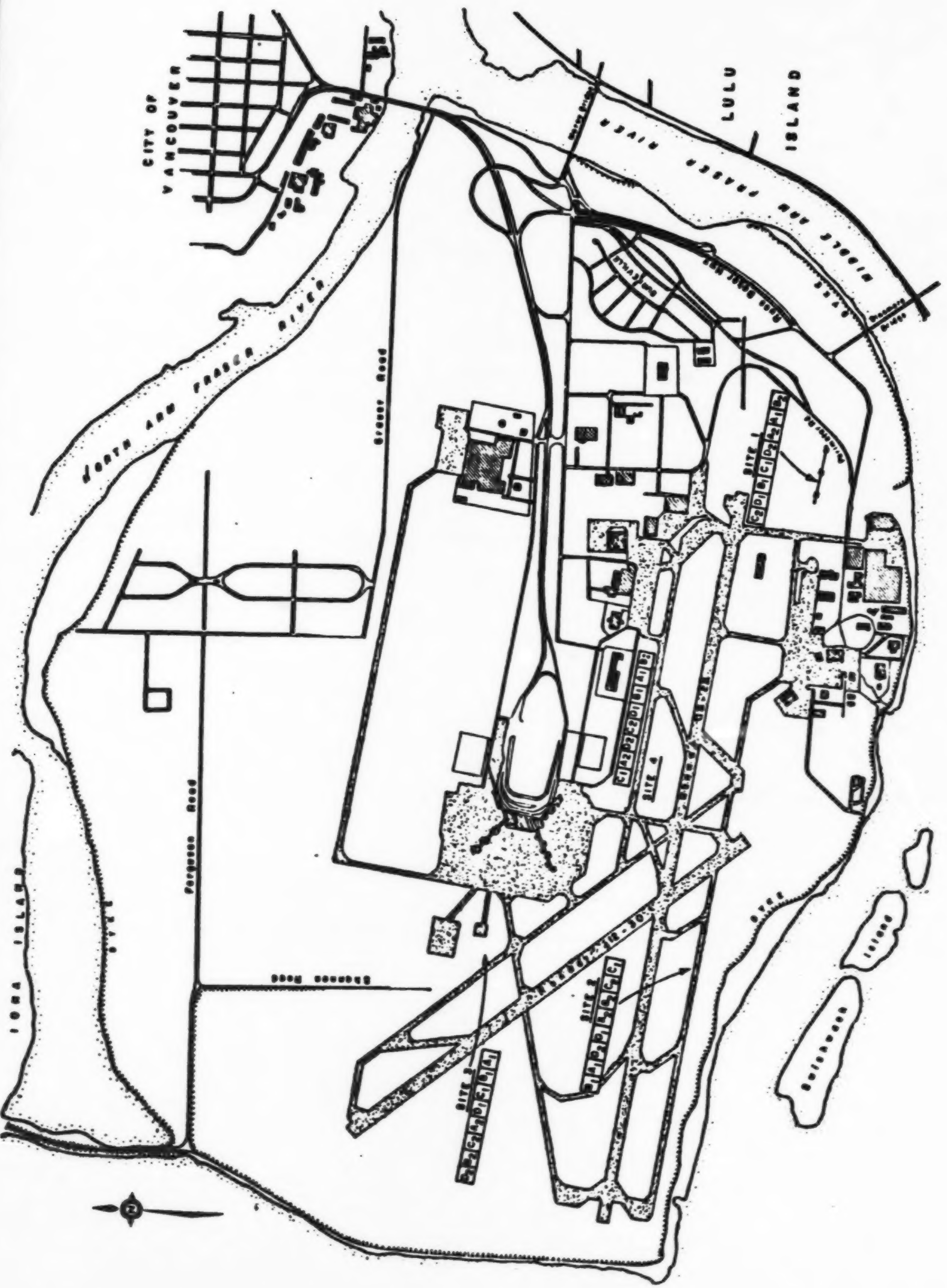

CITY OF VANCOUVER
LULU ISLAND
MIDDLE ARM FRASER RIVER
NORTH ARM FRASER RIVER
IONA ISLAND
DYKE
Grauer Road
Ferguson Road
SITE 1
SITE 2
SITE 3
SITE 4
Island

FIGURE 7-2 CRANEFLY STUDY AREAS - SEA ISLAND

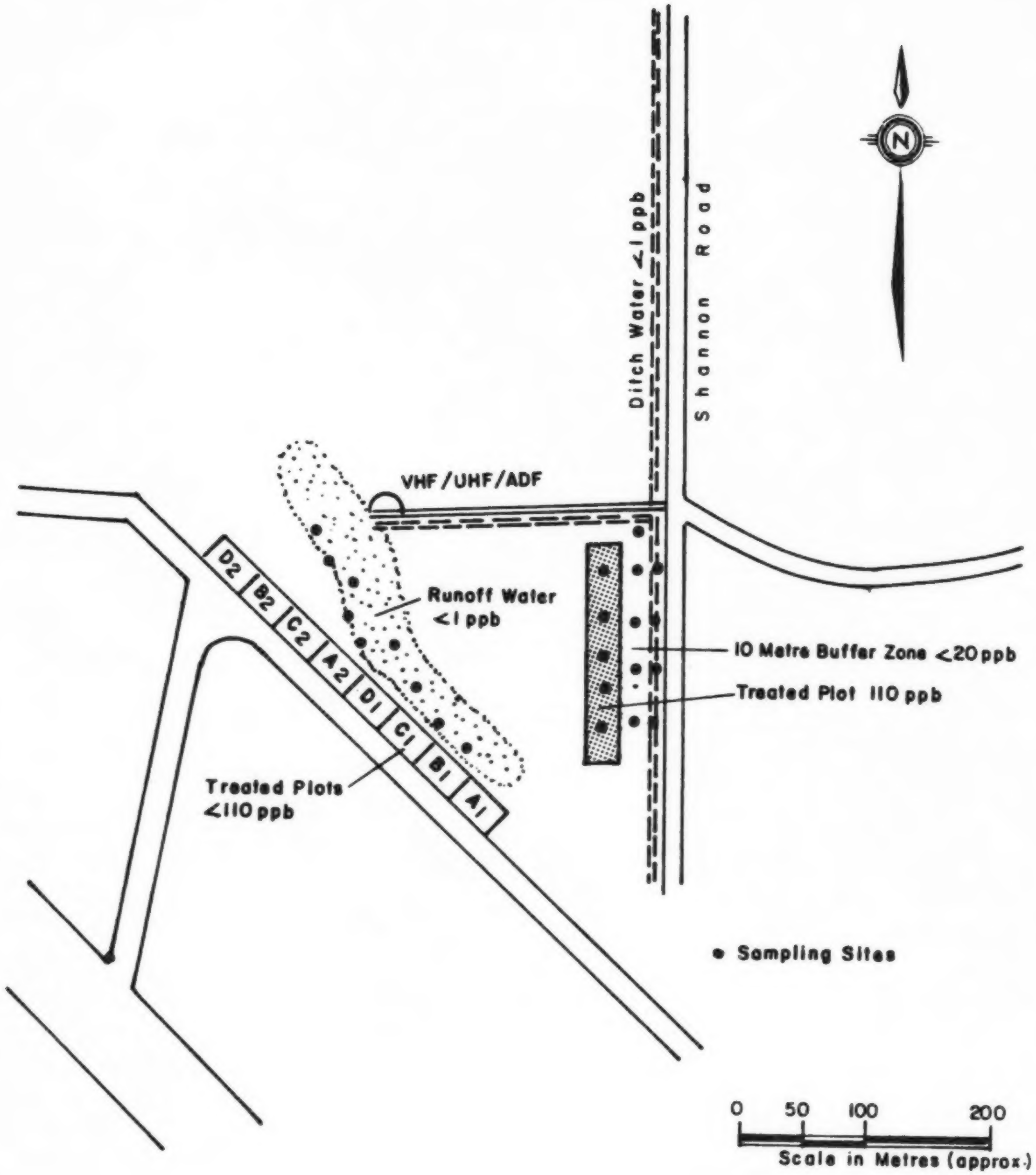

Ditch Water <1 ppb
Shannon Road
N
VHF/UHF/ADF
Runoff Water
<1 ppb
10 Metre Buffer Zone <20 ppb
Treated Plot 110 ppb
D2
B2
C2
A2
D1
C1
B1
A1
Treated Plots
<110 ppb
• Sampling Sites
0
50
100
200
Scale in Metres (approx.)

FIGURE 7-3 DIAGRAMMATIC LAYOUT OF SAMPLING POINTS AT SITE 3 - VANCOUVER INTERNATIONAL AIRPORT, RICHMOND

APPENDIX VIII

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